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SOLAR HALOS OF NOVEMBER THIRD.

FREDERICK SLOCUM.

During the forenoon of the third of November I was fortunate enough to observe a remarkably fine solar halo. It could not compare with the classic halos seen by Scheiner in 1630, Hevelius in 1661, or Löwitz in 1790, but yet seems worthy of description.

The first traces of the halo or group of halos, were noticed about 8 A. M. At that time the whole western part of the heavens was apparently clear, while in the east and southeast, especially in the vicinity of the sun, were many cirrus and cirro-stratus clouds. At 9 A. M., when the sun was about 18° above the horizon, the phenomenon reached its finest development.

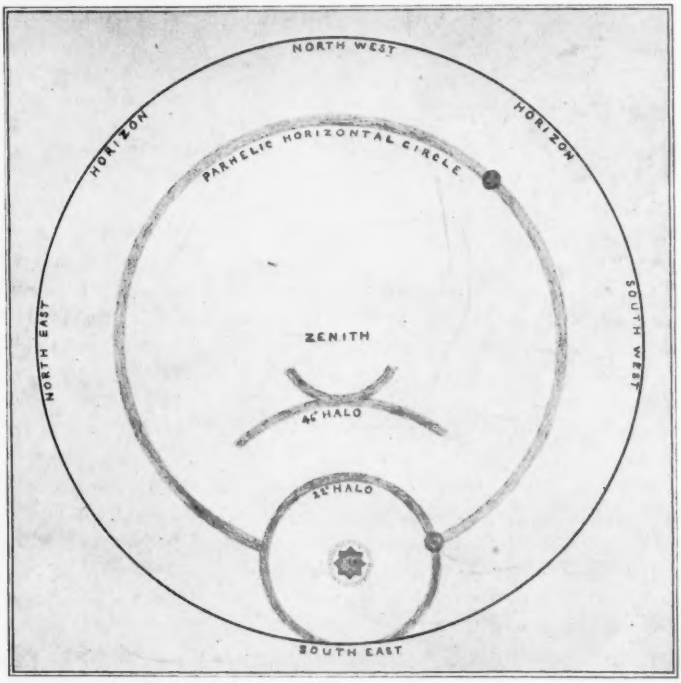
The halo of 22° radius was complete except for the small portion cut off by the horizon. The general appearance was similar to the effect that might be produced by a circle of brilliant light shining through thin clouds of varying density. The halo was continuous, but not uniform either in width or intensity. A very slight tinge of red on the inner edge was the only manifestation of color.

Outside of this halo, and concentric with it, was an arc about 120° in length and 46° radius. This was above the clouds and projected against a portion of the sky that was covered only by a very thin haze. The colors in this arc were as strongly marked as in an ordinary rainbow, the red being on the side toward the sun. The width was uniform throughout.

Tangent to the 46° halo at its highest point was another arc about 90° in length and having a radius of from 20° to 25°. This seemed to be the arc of a true circle with its center very near, if not exactly at, the zenith. Here again the colors were very strong. The red was on the side toward the center, that is, in this case, away from the sun.

Still another halo, the so called parhelic circle, was conspicuous. It appeared as a somewhat irregular band of light parallel to the horizon at the altitude of the sun, and formed nearly a complete circle. No trace of color could be detected in it.

Near where this circle cut the 22° halo on the south side was a brilliant patch of light shining through the thin clouds. This



Solar Halos seen at Williams Bay, Wis., Nov. 3, 1911.

is what a sailor would call a sun-dog, but in scientific language is known as a mock-sun or parhelion. There was no similar appearance to the north of the sun, nor was there any trace of the parhelia which are sometimes, though rarely, seen on the 46° halo. There was, however, a bright spot on the parhelic circle in the southwest. Unfortunately its exact position was not determined, but it probably was the southern paranthelion, although the anthelion, or antisun, itself was not observed. The accompanying diagram, shows the relative posi-

tions of the different halos. No attempt has been made to draw them to scale or to represent their actual appearance in the sky.

These phenomena, as is well known, are produced by the refraction and reflection of sunlight by ice crystals in the atmosphere. For an explanation of just how the different arcs are formed, why some show all colors from red to blue, why some have the red towards the sun and others the red away from the sun, and why still others are not colored at all, consult the article on halos in the Encyclopedia Britannica, eleventh edition, or text-books on light or optics.

In weather lore halos, both solar and lunar, have played an important part. The Greek poet Aratus, writing about 250 B.C., tells us

> "And foul weather expect, when thou canst trace
> A baleful halo circling Phoebus' face.
> If of two circles fouler weather fear."

And again referring to the mock-suns,

> "If two such satellites the sun attend,
> Soon will tempestuous rain from heaven descend:
> If one, and north, the northern wind prevails;
> If one, and south, expect the southern gales."
>
> J. Lamb's "Aratus."

The justification of these weather proverbs seems to be that the ice crystals and high cirrus clouds, which are essential to the formation of halos, are associated with the outflowing winds over areas of low pressure, and these areas are generally accompanied by stormy weather.

In the present case, when the observation was made during the forenoon of November third, there was an extensive area of high pressure central over Indiana, with a "low" in Canada just north of North Dakota. Before noon of that day the sky became completely overcast. The area of low pressure gradually moved toward the southeast, and storm conditions prevailed throughout the upper Mississippi valley for the next three days.

Williams Bay, Wis.
November 11, 1911.

PECULIAR MOVEMENTS OF THE SUN, EARTH AND STARS.

JOHN CANDEE DEAN.

Poincaré the eminent mathematician of the Institute of France, justifies modern industries on the ground that they will, in time, give us the leisure to contemplate nature. Machinery is useful because in doing work it will give us more time to study natural science. Poincaré says—"It is astronomy that has given us a soul capable of comprehending nature. It shows us how small is man's body, how great his mind, since his intelligence can embrace the whole of this dazzling immensity, and enjoy its harmony."

Astronomy is not only the favorite science of poets, but it strongly appeals to the popular imagination, because it deals with the immensity of space and is the science that predicts events. We must not be afraid of big numbers, even when told that the distance of the nearest fixed star, visible in our latitude, is expressed in miles by writing down the figure four and adding thirteen ciphers, or that light vibrates four hundred millions of millions times a second, and travels one hundred and eighty six thousand miles a second, and that some stars are so remote that it takes thousands of years for their light to cross the enormous abyss that separates them from us.

No branch of astronomy excites greater public interest, by reason of recent discoveries, than that which relates to the movement of the sun, the earth, the socalled fixed stars, and the drifting of star clusters and nebulæ. Up to the seventeenth century the earth was supposed to be the fixed center of the universe. We now speak of the sun as a fixed center of the solar system, but this idea of fixedness is correct only so far as its relation to the bodies revolving around it are concerned. It is difficult to even imagine a stable body in space. The nearest that we can come to it, is to try to conceive of a body whose motion is a mean of all the complex motions of the stars of the surrounding stellar system. It is highly improbable that any star has such a motion.

In the seventeenth century Halley observed that some of the brightest stars had changed their places since the time of Hipparchus, who lived in the second century B.C. In 1783, William Herschel concluded that the sun was moving in the

direction of Lambda, of the constellation of Hercules. Seventy years ago Struve demonstrated that the sun, with its community of planets, satellites, asteroids, comets and meteors, was

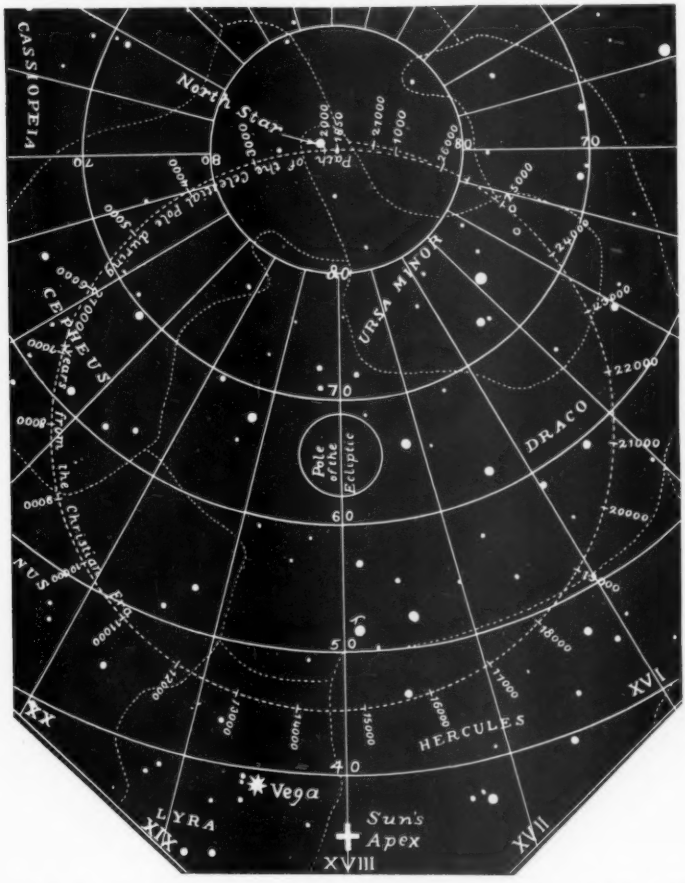


FIG. 1 Showing the movement of the Celestial Pole around the pole of the ecliptic and the location of the Sun's Apex.

flying through space with inconceivable velocity in the direction of the constellation Hercules. Later Mädler, of Dorpat, announced that the sun was moving around a central orb, in a period of 18,000,000 years. There is no evidence that the sun is deviating from a straight line. Among authorities,

there has been considerable range as to the exact point toward which the sun is flying, but it will be found that they nearly all agree that the general direction is toward the constellation of Hercules, near the point first assigned by Herschel and Struve.

In Fig. 1 the solar apex is shown, about seven degrees southwest of Vega, just within the border of Hercules on the XVIII hour circle, or 270° right ascension and 35° north declination. The position of the apex is indicated by a cross near the bottom of the drawing. It thus falls on the winter solstitial colure, according to the determination made by Professor Boss in 1910.

Fig. 1. shows that part of the north polar regions embraced by the path of the celestial pole. The pole of the heavens is the earth's pole extended into the heavens. The reader will therefore see that the movement of the celestial pole is due entirely to a motion of the earth. The time required to carry the pole all the way around the circle is 25,300 years, but this drawing shows its movement from the beginning of the Christian era, and it, therefore, represents a period of 27,000 years. It has been found that the sun is moving toward its apex with a velocity of about twelve miles a second. To realize what this means, consider that the muzzle velocity of a shot from a large modern cannon is only 1500 feet per second, while the sun moves with a speed of 63,000 feet per second, or forty two times as fast. If a cannon shot could be projected with the velocity of the sun, its energy and penetrating power would be increased 1700 times, and if a shot could be made that would withstand the enormous pressure and heat generated, it would penetrate 1500 feet of solid steel. Practically, however, a steel shot moving at this velocity and striking such a thick, solid steel plate, would be instantly fused by the heat generated from impact.

The earth's mean velocity toward the apex is, of course, the same as that of the sun, while its orbital velocity is 18½ miles a second. In Fig. 1, the apex of the solar way is placed on the XVIII hour circle, hence the line of the solar way, the axis of the ecliptic, and the celestial axis, are all in the same plane. This plane is perpendicular to the plane of the ecliptic and passes through the line of the ecliptic at the solstitial points. By examining the celestial polar circle it will be seen that about the year 8000, the celestial pole will be carried 23° east of this plane, but about the year 14,700, its axis will again swing back into the plane of the axis of the ecliptic and of the sun's way. The celestial pole will then be only 10° from the sun's apex.

At the beginning of the Christian era the pole star was 10° from the true north pole of the heavens. Since then the pole has

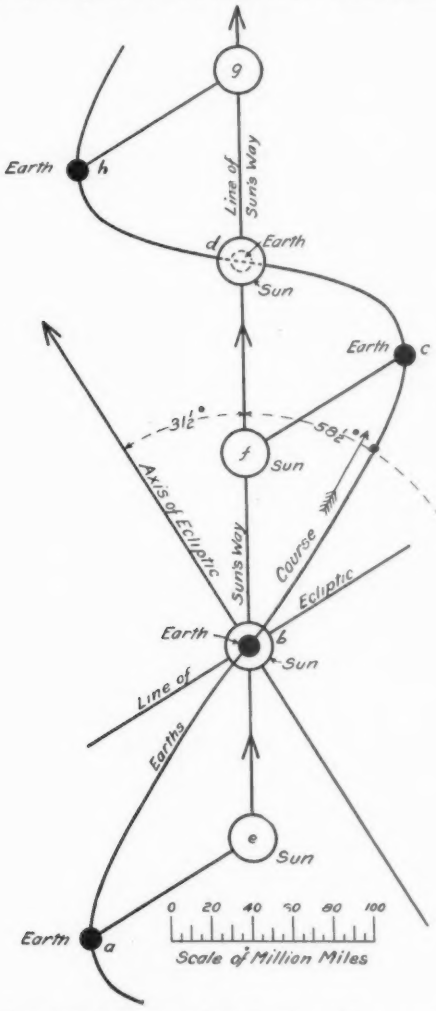


FIG. 2. Showing the course of the Earth and Sun toward the Apex during twelve months.

been approaching this star and it is now only 1¼° from it, and about the year 2100 will slowly pass within less than a half degree of the star. In 12,000 years from now, the pole of the

heavens will be shifted into the constellation of Lyra, and the splendid star Vega—seen near the bottom of drawing—will then be the pole star.

The star called 61 Cygni, in the constellation of the Swan, is the nearest star visible in our latitude. While the sun moves nearly 400,000,000 miles in a year, it would take 100,000 years for it to move over a space equal to the distance that separates us from the nearest star. In the sun's flight toward its apex, it will take over 500,000 years for it to pass the star Vega, but since Vega has a slow motion at right angles to the sun's motion, it follows that the sun will never pass very near that star.

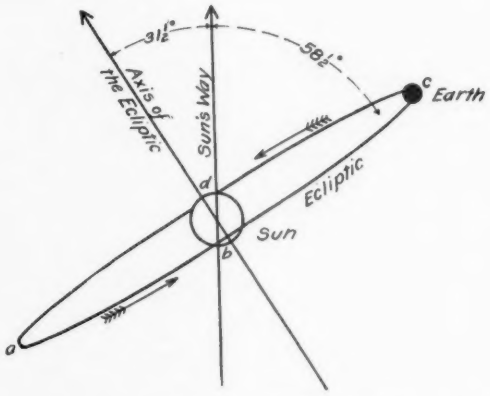


FIG. 3. Showing the relation of the Ecliptic to the Sun's Way.

While the sun moves at a uniform rate and probably in a straight line, the earth, owing to its motion around the sun, describes a huge spiral in space. Because the plane of the earth's revolution is inclined to the line of the sun's way, a variable motion of the earth toward the apex is produced. Referring to Figs. 2 and 3, the earth's motion toward the sun's apex is seven times as rapid at "b" as at "d". At "b", the velocity is 21 miles a second, while at "d" it is only three miles a second. Fig. 2 shows the course of the sun and the earth during a period of one year. The first three months the sun moves from "e" to "b", and the earth from "a" to "b". The second three months the sun moves from "b" to "f" and the earth from "b" to "c". The third quarter, the sun moves from "f" to "d" and the earth from "c" to "d". The last

quarter the sun moves from "d" to "g", and the earth from "d" to "h". Fig. 4 is introduced to show the helical course in which the earth actually moves through space during a period of eighteen months,

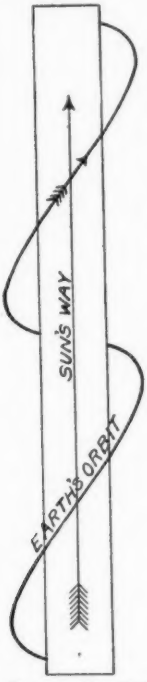


FIG. 4. The Helix described by the Earth in its progress towards the Sun's Apex.

Knowledge of the apparent velocity in line of sight, combined with the apparent transverse or angular movement, enables the astronomer to determine the true direction and true velocity of stars. On knowing the angular velocity, the true direction, and the radial velocity of a star, the more important fact of its distance from the earth can be deducted. This new method of computing stellar distances can be applied to stars so remote that no sensible annual parallax can be instrumentally detected. The usual method of calculating stellar distance from the annual parallax can be satisfactorily applied only to the nearest stars, because the semi-diameter of the earth's orbit of 93,000,000 miles, forms too short a base line for reliable calculation of these enormous distances. While the parallaxes of some 400 stars have been determined by the old method with more or less accuracy, the Nautical Almanac recognizes but three stars whose parallaxes are reliably known, viz: Alpha Centauri, Sirius and 61 Cygni.

It has been proposed to use the proper motion of the sun in space as a base line, because it furnishes a much longer line than the semi-diameter of the earth's orbit. The sun moves about 400,000,000 miles annually, hence stars viewed one year apart may be considered as observed from two different points in space, 400,000,000 miles apart. This base line may be indefinitely lengthened by increasing the length of time between observations. In ten years the line would be extended to about four thousand million miles.

In our own time it has been discovered that large groups of stars are migrating across the sky; the stars of each group moving in the same direction, with a nearly uniform rate of motion. Proctor called this "Parallelism and equality of motion." One of the best examples of cluster parallel motion is in the Pleiades. Another is in the Great Bear; five of the

seven stars in the "Big Dipper" are moving in one direction and at nearly the same velocity. Thirty-nine stars in the constellation of Taurus are moving toward a common point, and it is estimated that in sixty million years they will form a cluster smaller than the space now occupied by the Pleiades. The spectroscope enables the astronomer to determine the radial velocity of stars from the spectra of their light. This is the velocity with which they move in the line of sight, toward us, or from us; the wave length of light being shortened or lengthened by the star's motion.

At the Heidelberg Observatory they have a method of finding the proper motion of faint stars by looking through a stereoscope at photographic plates of the same part of the sky taken several years apart. Research in the movement of stars has yielded the interesting information that Sirius is moving with the group of seven stars in the Great Bear above referred to. Sirius is in a different part of the heavens from the Bear, and since Sirius marks the mouth of Canis Major, the following remark of Mr. Eddington is apropos of their relations: "It would have been an interesting theme for the classical mythologist to explain how so important a part of the Great Bear has come to be situated between the teeth of the Great Dog." Professor Stroobant has carefully determined the absolute velocity of the following seven conspicuous stars in different parts of the heavens, which were selected by him on account of the smallness of their proper motion: Schedir, Algenib, Algol, Antares, Gamma Cygni, Epsilon Pegasi, and Alpherat. He found that their velocity was not very different from that of our sun, and what is more remarkable, the direction of movement of the eight bodies was found to be parallel within a range of of six degrees. It may, therefore, be said that the sun belongs to, and is moving with, this group of stars.

A remarkably interesting phenomenon of two great drifts of stars moving in opposite directions has recently been discovered. About 10,000 stars were dealt with in this investigation. The *fast moving* drift is flowing away from the constellation of the Serpent Bearer. The *slow moving* drift is flowing from the constellation of the Lynx. The two streams of stars appear to be nearly equally divided and are completely intermingled with each other. The phenomenon is explained on the theory that two great universes have been drawn together, probably by mutual attraction, and are now passing through each other. Because of the enormous distance between indi-

vidual stars, the chances of collisions between them are very small. It must not be assumed that the discovery of the phenomenon of the two opposing stellar drifts has upset the theory as to the position of the solar apex; on the contrary, its position calculated in this way satisfactorily agrees with that found by the other method.

October 26, 1911.

SOLAR AND LUNAR DECLINATION.

FREDERICK CAMPBELL, Sc. D.*

In a recent article in POPULAR ASTRONOMY, the writer sought to explain the "Vagaries of the Moon," showing how it is at times very much higher in the heavens than at other times. The relations of sun and moon in the matter of declination are dealt with in the present article.

Inasmuch as new moon occurs when the moon is passing the sun, and inasmuch as the moon can never be more than five degrees removed from the sun's path, it is evident that, when the sun is high, the new moon is also high; and when the sun is low the new moon is also low. Whatever be the declination of the sun at time of new moon, whether high, low or medium, the moon will never vary from it more than five degrees north or south.

On the other hand, inasmuch as full moon is always opposite the sun, when the sun is high, full moon will be low; and when the sun is low, full moon will be high; but when the sun is medium, full moon must also be medium. To express the matter otherwise, full moon is always found opposite the sun's present location, and not more than five degrees from where the sun will be six months later. Thus June's high sun sees the full moon lying low, close to where the winter sun will be in December; and December's low sun sees the full moon riding high, close to where the sun will be in June.

The cases of the first and last quarter phases are not so

*Second Vice President Department of Astronomy, Brooklyn Institute.

familiar. But, being acquainted with the course of the sun, there ought to be no difficulty in figuring out that of the moon. The moon runs on ahead of the sun, after new moon, and at first quarter reaches that region where the sun, will be three months hence; for it takes the moon only one week and a little more to traverse the arc covered by the sun in three months,—one quarter around the heavens. Hence it is easy to see that, in March, for instance, the moon at first quarter will be where the sun will be in June, that is, high; and that in September, the moon at first quarter will be where the sun will be in December, namely, low. In June, on the other hand, the moon has run ahead, for the first quarter, to the sun's September position at the time of the autumnal equinox; and in December it has advanced to the sun's March position at the time of the vernal equinox; both these postions are neither high nor low, but medium.

As for last quarter, the moon is now overtaking the sun again, and occupies the region where the sun was three months previously. Thus, when the sun is at the vernal equinox in March; the moon at last quarter is travelling where the sun was in December, namely, low; and, when the sun is at the autumnal equinox in September, the moon at last quarter is travelling where the sun was in June, namely, high. In June, on the other hand, when the sun is high, the moon at last quarter is following in the region where the sun was in March; and in December, when the sun is low, it is following where the sun was in September, both of which lunar positions at last quarter are equinoctial, of medium declination. Of course allowance must be constantly made for the swing of the moon five degrees north and five degrees south of the sun's path, or the ecliptic.

The following table will help to make all this clear:

TABLE OF SOLAR AND LUNAR DECLINATIONS.

Season	Sun	New Moon	First Quarter	Full Moon	Last Quarter
June	High	High	Medium	Low	Medium
September	Medium	Medium	Low	Medium	High
December	Low	Low	Medium	High	Medium
March	Medium	Medium	High	Medium	Low

REVIEW OF POINCARÉ'S LECTURES ON COSMOGONY.

T. J. J. SEE.

The work which we review is a course of lectures just given at the University of Paris, by the eminent French mathematician Poincaré, who has occupied himself largely with mathematical physics and of late years more and more with astronomy. The present course is edited by Dr. Henri Vergne, and published by A. Hermann et Fils, Paris, 288 pages octavo, plus XXV pages of Introduction. Everything written by Poincaré is worthy of attention, and this course of Lectures will be welcomed by many readers, though the author aimed at giving a summary of different views, rather than at developing a single consistent theory. There is thus some discontinuity in the work, but the discussion of the different hypotheses is well developed; and the mathematical analysis which Poincaré introduces into the theories of Kant, Laplace, Roche, Faye, Ligondes, and others, will prove useful to the future student of the subject. Heretofore the treatment has often been non-mathematical in character, and thus the theories could not be subjected to exact tests.

Two chapters of the work are devoted to particular topics from the second volume of my *Researches on the Evolution of the Stellar Systems*, 1910, namely the theory of the Resisting Medium and the Capture of Satellites, and the theory of Spiral and Ring Nebulæ. As my volume reached M. Poincaré after nearly all his lectures were finished, this naturally precluded a fuller treatment of the results established in the new work.

He remarks that the Resisting Medium gives a satisfactory explanation of the roundness of the orbits, and the Capture of Satellites, and he evidently inclines to the new explanation of the Spiral and Ring Nebulæ, and also to the impact theory of the Lunar Craters.

As regards the inclinations Poincaré considers my explanation unsatisfactory, but it is because he has slightly misunderstood the theory. He assumes that I imagine the bodies to enter the nebula quite at random, in any plane, whereas I specifically require the original nebula to be of unsymmetrical figure, made up of two or more streams settling or coiling up, in a plane of maximum areas, and thus giving the system from the first a fundamental plane, in which the planetary nuclei originate.

The smaller masses, such as comets and meteoric dust, do indeed enter the primitive nebula from all directions; and it is by the destruction of these small bodies that the larger bodies are gradually built up, and drawn towards the center, in orbits lying near the fundamental plane and becoming ever rounder and rounder. Bodies revolving in overlapping orbits are eventually destroyed, as actually witnessed among the comets of the solar system within historical time.

It is remarkable that M. Poincaré quite overlooks the important dynamical criterion introduced by the French Physicist Babinet in 1861. One is surprised also to notice in one part of the introduction (page VI) an expressed preference for the old theory of Laplace, and then again (page XXIV) a more general admission that the theory of Laplace is inapplicable to the Universe generally. If Poincaré had studied my discussion of the results which follow from Babinet's Criterion he could have rejected once for all Laplace's Theory and the modifications of it proposed by Roche, Faye, Ligondes, etc, and thus greatly simplified his treatment. But, as stated above, my large work did not reach him till the lectures were nearly finished; and of course the inconsistencies here noted were characteristic of the whole subject prior to the publication of that work. Some allowance must therefore be made for the previous chaotic state of the subject.

The problem of the internal heat of the sun and planets is very briefly treated, though the latest and fullest developments are not included. One finds also a discussion of molecular theories, carried through the work. Some of these theories, such as those of Maxwell and Arrhenius, are worthy of attention, and Poincaré's survey of the subject will prove valuable to students. Altogether this volume of the eminent French Geometer is a welcome addition to the literature of science, and in spite of the defects mentioned will sustain Poincaré's reputation as a mathematician and natural philosopher.

Mare Island, California,
November 22, 1911.

A MODERN LOOK AT THE UNIVERSE.

HENRY OLERICH.

Continued from page 637.

Contraction and Expansion of Matter.

The molecules, atoms, and electrons of all known substances do not seem to be packed close together; but have comparatively large interstices or "pores" between them. This property of matter is known as *porosity*, and can be demonstrated in various ways by practical experiments.

For example, a considerable quantity of common salt may be slowly put into a bottle already level full with water without increasing the volume of water in the bottle, on the theory that the molecules of salt lodge in the interstices between the water molecules. In testing large cannon by hydrostatic pressure, the water molecules are forced through the thick steel walls of the cannon, showing that the molecules of steel forming the walls of the cannon are so far apart as to let the molecules of water pass out between them, and so with all other forms of known matter.

Of the particular *form* of molecules, atoms, and electrons little or nothing is yet known, but they are supposed to be all in constant motion of some kind, held together by attractive forces, and kept certain distances apart by heat or repulsive forces. In general, the higher the temperature of a certain mass of matter, the larger the volume, the larger the interstices between the molecules, atoms, and electrons, and the more violent seems to be their individual motions.

That heat *expands* matter and cold contracts it is a well-known characteristic of matter. The blacksmith heats the tire when he sets it. A bottle level full of water set on a warm stove will soon overflow, and the hotter it becomes the more will run out. The increased temperature of the water, does, however, not increase the mass, weight, or number of molecules; but merely increases the volume of the water by forcing the molecules farther apart, so that some of them had to vacate the bottle. Hence, roughly stated, an increase in temperature produces a corresponding *expansion* in volume, and a decrease produces a corresponding *contraction* in volume; but as before

intimated, temperature affects neither weight nor mass. Without the operation of these thermal laws and principles, our solar system could not have evolved to its present form and function as suggested by the Nebular Hypothesis.

Transmutation of Matter and Energy.

Before we proceed with our investigation of the Nebular Hypothesis, which rests for its truth on the transmutation of matter and energy and motion, it will be interesting as well as profitable for us to take a brief glance at the wonderful changes that are ever going on around us.

As before intimated, science teaches that the matter, energy and motion composing the universe are *eternal*, and the *total quantity* always the same; that the number of molecules and atoms may vary from time to time according to the physical and chemical complexity of their structure; but that the number of ultimate electrons is forever invariable. It seems that all the countless varieties of forms and functions are due to the particular combination and arrangement of electrons, atoms and molecules as we see beautifully exemplified in many of our daily experiences.

For example, a drop of water may be converted into a ball of ice by cooling it below 32 degrees, or converted into a large volume of invisible steam by heating it above 212 degrees; the sunbeam or solar energy silently and invisibly evaporates the countless minute particles of vapor, wafts them north where they again unite by cooling as drops of falling rain or snow, forming the great Mississippi river system flowing south as a liquid. It thus keeps on making the round; south as a liquid river; north as an invisible aerial current.

Again; the sunbeam or solar energy impinges against the green leaf of the growing radish in the garden. This produces chemical changes in the sap of the plant, which enables it by the aid of roots and leaves to transform part of the inorganic garden soil, moisture, and surrounding air into a growing, *organic* radish. This plant we eat, digest, and assimilate into human *organs* and physiological and psychological *functions*.

Energy, like matter, is therefore also ceaselessly transmuted from one form into numerous widely different forms. For example, the energy or motion of a rushing waterfall may be converted into that of a powerful rotating water-wheel; the motion of this rotating water-wheel may be reconverted into a rapidly rotating dynamo, generating powerful currents of electricity;

the electricity may be transmuted into a brilliant electric light; run the machinery in the factory; cook the meals and wash the dishes in the electric kitchen; iron the garments in the laundry; heat the store, factory and residence; or it may be stored away for future use in the electric storage battery cell of the electric automobile, which may be used for riding, freighting, gardening, and farming on a large scale.

Are not these marvelous transformations of matter and motion? But this is neither the end nor the beginning. We ask what keeps the water-fall going. Is it not the solar energy coming from the sun? Do not the sunbeams cause the tiny molecules of watery vapor to evaporate and then be carried to the sources of the river-system, where they again fall as rain or snow, which supplies the river and water-fall with a continuous stream of rushing water? Thus forming an endless recurring cycle of transmutation of matter and energy; and, as a whole, without the slightest loss or gain.

Thus we may see by what circuitous route the energy which combines and separates the molecules, atoms, and electrons composing the air, water and soil of the field and garden may be slowly and silently transmuted into a brilliant eye, a keen ear, a skilful hand, a stomach capable of digesting, a nerve-fiber thrilling with the emotion of love, and the marvelous brain functioning mentality. And all this endless variety of form and function seems to be due to the peculiar combination and ceaseless arrangement and rearrangement of electrons, atoms, and molecules. From the soil to the plant; from the plant to the animal, and after death, the lifeless organisms and their vital energies again disintegrate, and the same electrons become once more earth, air, water, or a constituent part of some other organic being. In this visible manner may the recurring cycles of transmutation of matter and motion be seen to continue on a small scale in endless succession, if we but have open eyes to see, and thoughtful minds to observe and think.

In the same manner, but on a much grander scale, does the Nebular Hypothesis endeavor to explain that our solar system slowly evolved in obedience to the same laws of transmutation of matter and energy from a glowing, homogeneous nebula to its present concentrated form and function. At this primitive "beginning" of the nebulous sun, the heat was perhaps so great that the chemical formation of atoms and molecules was not yet possible; so that each electron was then perhaps

a separate entity, a little world of its own far removed from its nearest neighbor, but holding within itself all the potentialities of future coöperation with other electrons, slowly producing by successive steps the progressive transmutations of matter and motion, the endless and ever changing varieties of form and function—chemical, physical, biological, social, and psychological—with which our world, and no doubt, billions of other worlds are now so richly endowed.

Let me here suggest that it makes little or no difference for our purpose, whether we hold that matter is a *form* of *energy*, or energy a *form* of *matter*; or whether the two are really one. The two always seem so be indissolubly united; for we know of no energy apart from, and independent of, matter; nor do we know of any form of matter incapable of manifesting energy and motion.

Gravitation and the three laws of motion.

There is one other important topic that should briefly engage our attention before we proceed to investigate the evolution or spontaneous transmutation of our solar system from a primal mist to its present complex form and function.

Science is founded on the uniformity of nature and the universality of law; on the principle that the universe is a universe of cause and effect; a universe of immutable law, the correct understanding of which enables us to look backward and forward in time, and the more completely we understand the operation of these natural laws, the farther can we look either way. Prevision—ability to look backward and forward in time—is, therefore, the characteristic and the test of knowledge.

That is what the astronomer does when he predicts eclipses; the electrician when he installs a power-station; the architect when he makes his plans and specifications; the inventor when he plans his invention; the housewife when she mixes her dough; and even the farmer when he plows and sows his field with the expectation of reaping a harvest in the not distant future. The success of all this depends on how well we understand and coöperate with the operation of the natural laws that produce the phenomena.

One by one has man discovered, so far as we now know them, this intricate network of natural law. In fact, the science of modern astronomy may be said to begin with the publication of Newton's *Principia* in 1687. Sir Isaac Newton discovered and elucidated the Law of Gravitation and his three Laws of

Motion. They are perhaps the most important and far-reaching discoveries that have ever been made by any one human mind; and without a fair understanding of these laws, we can not hope to get a good mental grasp of how our solar system slowly evolved its various members from a huge gaseous nebula to their present concentrated forms and functions.

Newton's law of gravitation is:

Every particle of matter in the universe is attracted by every other particle with a force directly proportional to its quantity, and inversely as the square of the distance.

That is, the attractive force of ten similar particles of matter is ten times greater than is the attractive force of one particle, and so on in proportion to mass at *equal* distances; but with respect to distance, the attractive force *decreases* as the *square* of the distance increases. A body three times as far away is attracted only one-ninth as much, and so on, as the square of the distance increases.

Newton's laws of motion are known as the *First*, *Second*, and *Third* Laws of Motion.

FIRST LAW: A body set in *motion* will move forever in a straight line with uniform velocity, unless acted on by some *external* force, and when once at *rest*, it will forever remain at rest, unless some external force starts it.

For instance, a planet or other heavenly body moving in a vacuum, will never stop, unless it is acted on by some outside force. If this moving planet were the only body in the universe, so that it would not be attracted from its course by other bodies, it would forever move in a straight line with uniform velocity. This characteristic of matter is known as Newton's First law of motion, and is a very important one in helping to solve the riddle of the Universe. According to this law of motion, it is as natural for matter to be in motion as it is for it to be at rest.

SECOND LAW: A force acting upon a body in motion or at rest, produces the same effect whether it acts alone or with other forces.

For example, a planet revolving around the sun, keeps up its uniform motion in obedience to the First Law of Motion; but it does not move in a *straight* line, because the sun's gravitation, as a second force, deflects it so much every second from a straight line; it is falling toward the sun so many feet every second, which causes it to describe a curve or circle instead of a

straight line. Hence, each of these two forces acts as if it were the only one acting on that body; and this is known as Newton's second law of motion.

THIRD LAW: Action is equal to reaction, and in opposite direction.

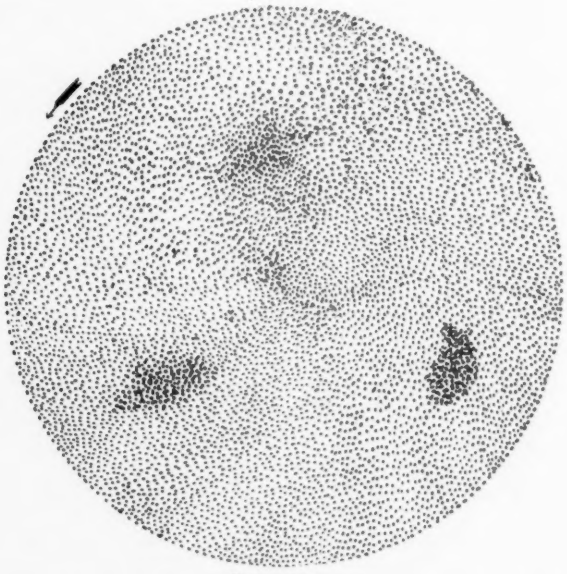


FIGURE 5.

Well-matured nebula out of which the solar system slowly evolved. Density about one ten-millionth that of hydrogen. Here the matter, energy, and motion of our solar system are still all in one mass. Astronomers have located more than 10,000 nebulæ, and are finding more every year. A few of them are visible to the naked eye; the others are telescopic.

For example, if two equal planets would collide in the same orbit from opposite directions, they would destroy each others orbital motion, for action is equal to reaction and in opposite directions. But after the collision, the wreck of the two planets would fall in a straight line into the sun by the force of his gravity.

WHY SUNS SHED PLANETARY RINGS.

As before suggested, the Nebular Hypothesis starts out with the assumption that our solar system evolved out of an immense, highly-heated, primal mist, which slowly rotated on its axis in a *cold vacuum*. Under these conditions, would this

primitive nebulous sun continue to rotate on its axis with uniform velocity in accordance with the first law of motion as long as its spherical volume remained of the same diameter. But as this primitive sun was surrounded by a cold vacuum, it slowly radiated its heat, and this cooling process caused a slow but continuous shrinkage in volume, and in consequence of this contraction and rotation the rotary velocity ever continued to increase.

In a subsequent topic, we shall endeavor to explain by what mechanical law a contracting sphere that rotates ever so slowly on its axis must correspondingly ever increase its rotary velocity.

It is not difficult to understand, that if the rotary motion of the nebulous sun ever continued to increase, then a time would necessarily have to come, when the centrifugal force would overcome that of gravity, so that a broad, highly-heated ring or belt would be left behind from the exterior equatorial region of the rapidly rotating primitive sun.

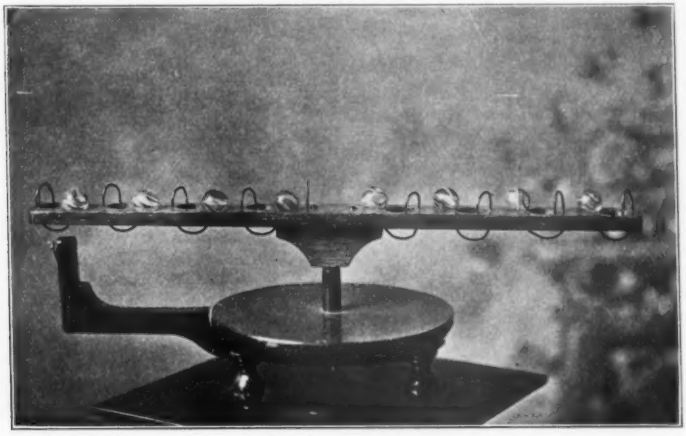


FIGURE 6.

PLANETARY ACCELERATING MACHINE.

The arm supporting the eight balls represents the equatorial diameter of a well matured and speedily-rotating nebula about to shed rings. As the rotary velocity of the arm is being gradually increased, will the outer ball at each end of the rotating arm be shed first, then the next two outer ones, and so on, the same as the planets and moons were successively shed at long intervals as a consequence of an ever-increasing rotary velocity of the sun and planets.

We can readily see that if the vacuum in which the nebulous sun was rotating had been as hot as the sun himself, a ring could then not have been shed; for the shedding of an equatorial ring must always be preceded by an increase of rotary motion, which must result from contraction, and contraction must be produced by radiation of heat, which could not have occurred if the surrounding space had not been cooler than the nebulous sun. It is true that contraction is itself a process of heating, which has to be overcome by an excess of radiation.

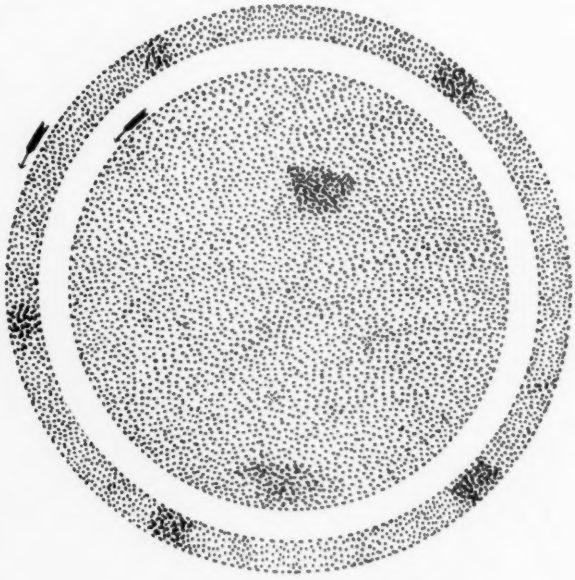


FIGURE 7.

First ring shed from nebulous sun. Unequal density of the ring will slowly gravitate it into several separate masses. The sun continues to shrink, and consequently ever increases his rotary motion, and the ring continues to revolve around the sun with uniform velocity in a circular orbit.

WHY PLANETS REVOLVE AROUND THE SUN.

In the preceding topic, we pointed out why, in the course of long intervals, rings detached themselves from the equatorial region, of a rotating plastic sphere, because of its ever increasnig rotary motion. Now we shall endeavor to explain how the

detached ring, or spherical planet, acquired its revolutionary motion around the sun; and why it forever continues its orbital motion with unabated velocity.

By referring to Fig. 7, it will not be difficult to see that the detached ring acquired its initial revolutionary motion from the sun's axial rotation at the time the ring was shed, and just so fast does the ring or planet still revolve around the sun, and the moons around the planets, unless some external force has since disturbed that relation.

We have seen that according to the first law of motion, it is as natural for matter to be in motion as it is for it to be at "rest", for when a body is once in motion, it will forever continue in motion in a straight line, and with uniform velocity, unless some outside force interferes; and when once at rest, it will forever continue at rest, unless some external force sets it in motion.

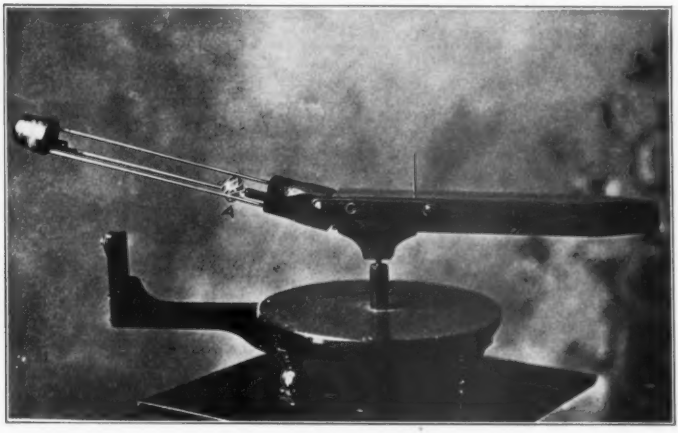


FIGURE 8.

PLANETARY REVOLVING MACHINE.

The pivotal center of the revolving arm represents the sun. The ball A represents a planet revolving round the sun, and easily rolls up and down on the steel rods, when the arm is revolving at a certain speed. The faster the arm revolves the farther will the ball recede from the center of the revolving arm. The ball is thus kept in equilibrium by the two forces—gravitation and the centrifugal tendency, the same forces that keep the earth and other planets and moons in their orbits.

But why then do planets and moons move in curves instead of straight lines? It is really not difficult to understand why they do so, when we keep in mind that their revolutionary movement is regulated by two continuous forces. The inertia of the first law of motion impels the planet forward in a straight line, and the force of the sun's gravity causes it to fall so many feet or inches toward the sun every second, so that these two forces just balance. Hence the circle instead of a straight line.

For instance, if the sun in Fig. 7, could be removed or annihilated, every particle composing the detached ring would then immediately proceed in a straight line instead of a curve. On the other hand, if the revolutionary motion were arrested, so that the ring or planet would come to a standstill in its orbit, it would immediately start to fall in a straight line into the sun by the one force of the sun's gravity.

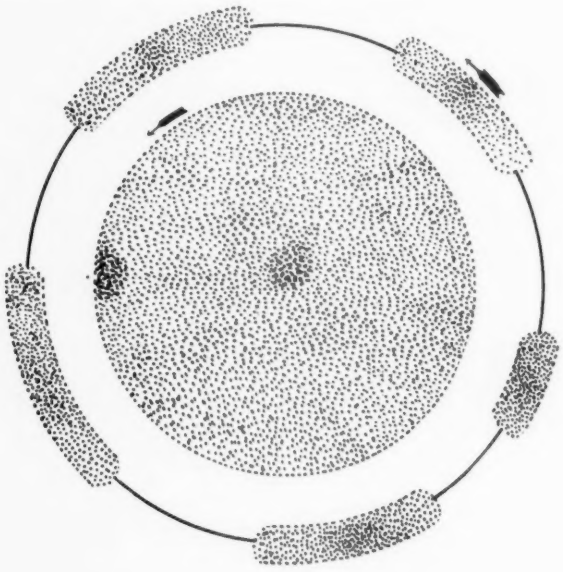


FIGURE 9.

Neptunian ring separated into five revolving masses that will be slowly drawn into one spherical mass by gravitation.

Transformation of the Detached Ring.

Our next point in the order of cosmic transmutation is to show why the rings break up into masses, and why all the masses finally gather into one mass out of which the spherical planet or moon is formed. We can readily see that it is practically impossible for a large nebulous ring to be perfectly uniform in density throughout every point of its structure. If there is only the slightest difference in the density at certain points, perhaps a difference of only one electron, then these slightly denser points at once begin to gravitate nuclei in the ring, each of which draws the surrounding mobile particles into a separate mass and all the masses, whether large or small, continue to revolve in the same orbit around the parent sun.

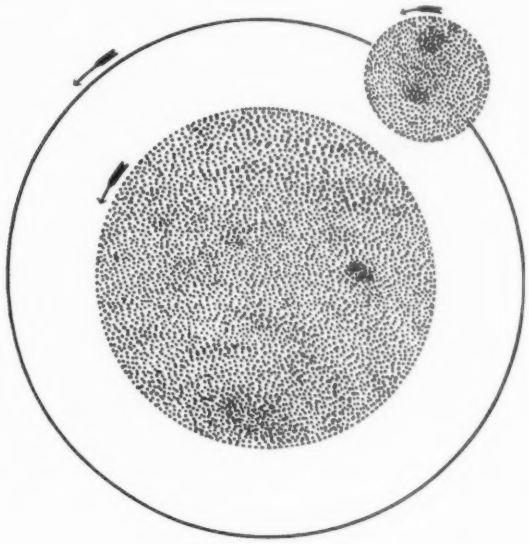


Figure 10.

The solar system is growing. It is now composed of one large, gaseous sun, and one large, gaseous planet. Both continue to contract, and consequently increase their rotary motion.

Finally all these revolving masses of the broken ring, some large, some small, chasing one another in substantially the same orbit, will, by the attraction of gravitation, all be slowly drawn into one large mass, forming itself in accordance with

the law of rotundity into a rotating spherical planet, and in obedience to the laws of motion and the law of gravitation as before explained, did the new planet continue to revolve in its original circular orbit around the parent sun with undiminished orbital velocity. Thus we see also how part of the rotary motion of the primitive sun was from time to time changed into the revolutionary motion of the rings out of which the planets and moons were later built. At this time, the orbit of Neptune was a perfect ellipse, since there was then no perturbation from other local planets and moons.

FIGURE 11.

A little oil globe floating in a mixture of alcohol and water. It assumes a spherical form, because all the surface particles are equally distant from its center of attraction, which is not the case in any other geometrical form.

WHY SUN'S PLANETS, AND MOONS ARE SPHERICAL IN FORM.

It is a well-known fact that suns, planets, and moons are spherical in form. The reason why plastic bodies when left substantially free in a vacuum, assume a spherical form is, that the sphere is the only geometrical form in which all the particles of matter composing the surface of the body are

equally distant from its center of attraction; and the same is true of all the successive layers below the surface layer. In no other geometrical form is such the case; and for that reason do free, plastic bodies assume a spherical form. We have familar examples of the operation of this law of rotundity in the falling raindrops, in the descending shot at the shot-tower, in the beautiful little oil globe in the bottle floating in a mixture of alcohol and water, and lastly in the countless millions of spherical heavenly bodies.

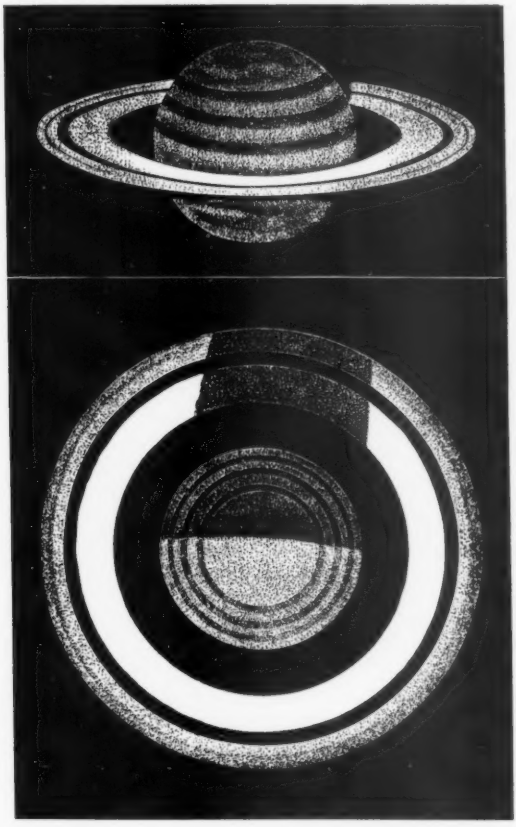


FIGURE 12.
SATURN'S RINGS.

The interesting experiment with the little oil globe is cheap and easily made. Take a square pint bottle, fill it half full of alcohol. Then pour in a large tea-spoon full of sweet-oil. While pouring in the oil, tilt the bottle a little, so that the oil will keep together and lodge in one corner at the bottom of the bottle containing the alcohol; for the sweet oil is about ten points heavier than the alcohol. Then gently pour in some water until the oil begins to be buoyed up by the mixture of alcohol and water, and forms itself into a beautiful little spherical world in obedience to the same physical laws of rotundity that causes suns, planets, and moons to assume a spherical form. The more water is poured into the bottle the higher will the little world rise in the liquid.

The Sun's Axial Rotation.

Astronomers have ascertained by the aid of sun-spots and other means that the present sun rotates on his axis once in about every twenty-five days and five hours. We have already stated that at the time the Neptunian Ring was shed, the primitive sun then required about a hundred and sixty-four years to complete one rotation on his axis. His diameter was then between five and six billion miles. Now it is less than one million.

As before intimated, it is not difficult to see how the initial rotary motion of the sun must have resulted from the coming together of the thinly scattered particles of primal mist from numerous directions and with unequal velocities, and perhaps unequal masses as gravity was slowly forming the surrounding mobile particles into an immense nucleus or primordial nebula, which slowly condensed into the primitive sun, and these unequal collisions from different directions were bound to produce at least a slight rotation on some axis of the accumulating mass; and as we have seen, this slight beginning furnishes the starting-point for an ever increasing rotary velocity as long as the contraction of the rotating sun continues.

When the ring out of which our earth was formed was shed, the sun then completed one rotation on his axis in about three hundred and sixty-five and a fourth days; and when Mercury was shed, the time for one rotation had been reduced to about eighty-eight days.

Thus we notice that the sun's diameter diminished from about six billion miles to less than one million; that the period of time required for one axial rotation has been

reduced from a hundred and sixty-four years to a little over twenty-five days and five hours at the present time. The present year of any planet is equal to the sun's day at the time that that planet's ring was shed. In this same manner will the sun, no doubt, keep on contracting and increasing in rotary velocity as long as he continues to radiate heat, so that he is still all the time preparing to shed another planetary ring, which he will, no doubt, do during the yet millions of years of his active future life.

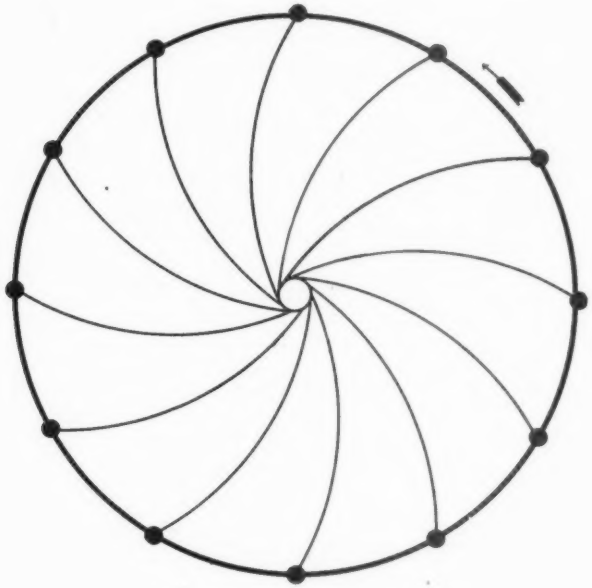


FIGURE 13.

Cross section of a centrally cut sphere. The small dark circles represent particles of matter, showing the curved paths, which, in a rotating sphere, they take in falling toward the center as the sphere contracts. The particles all fall slightly to the east of a vertical, and these one-sided collisions cause the ever accelerating rotation.

WHY ROTARY MOTION INCREASES.

Our next point for elucidation in the chain of causes is the ever increasing rotary motion of a contracting body that rotates on its axis. We have just noticed that the sun's axial rotation slowly but steadily increased during the millions of

ages in which the rotating sun shed at long intervals the successive solar rings out of which the planets evolved. Let us now briefly investigate the mechanical causes of this increasing rotary velocity, which caused the successive rings to be detached from the nebulous sun.

As we have seen, the Nebular Hypothesis starts out with the assumptions that the volume of the primordial sun was enormously large; that the matter was highly heated and consequently extremely attenuated—one ten-millionth of the density of hydrogen—that there was at least a slight initial rotary motion and that the sun continued to shrink in volume by reason of continually radiating heat into surrounding colder space; and all these assumptions are supported by an immense array of indirect evidence.

In accordance with a combination of mechanical laws, every contracting sphere that rotates ever so slowly on its axis must therefore continue to increase its rotary velocity as long as the equatorial dimensions continue to contract.

Why the rotary motion of a heavenly body thus continues to increase may be seen by examining a cross section of the centrally cut sphere shown in the accompanying illustration. This globe is supposed to rotate in the same direction as the earth and sun do, from west to east, and continue to contract in all directions by reason of radiating its heat. The small dark circles in the periphery at the equator of the cross section, each represent particles of matter continually falling by contraction toward the center of gravity of the contracting sphere.

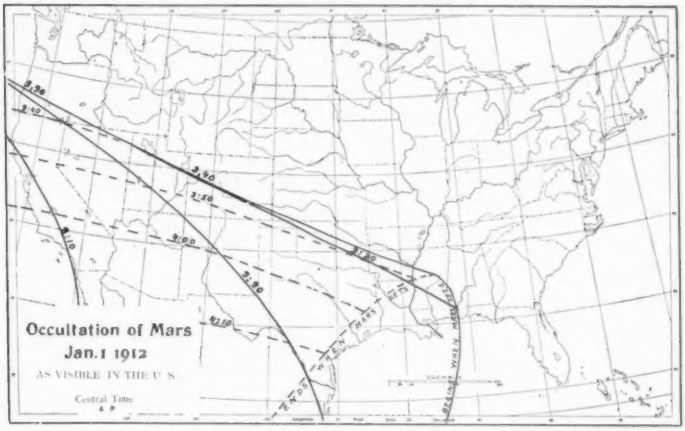
We can readily see that in a contracting globe having no rotary motion, all the particles fall in a vertical line toward the center of gravity as the sphere contracts; but in a contracting globe that rotates, the rotating particles fall in a slightly curved line, and a little in front of a straight, vertical line. These countless billions of one-sided molecular collisions cause the rotating body to further accelerate its rotary motion; and the faster the body rotates, the more rapidly does it increase its rotary motion, because the further are the molecules, atoms, and electrons whirled to the left of a vertical line against their neighbors, as the particles descend toward the center in the contracting sphere.

To be Continued

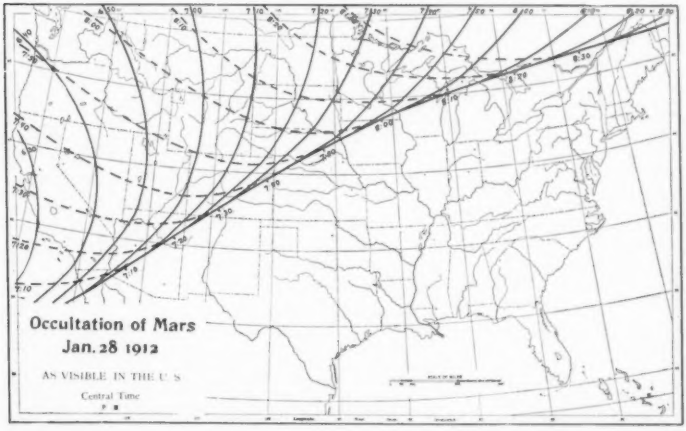
THE OCCULTATIONS OF MARS OF JANUARY 1 AND 28, 1912, AS VISIBLE IN THE UNITED STATES.

WILLIAM F. RIGGE, S. J.

The occultations of Mars of January 1 and 28, 1912, will each be visible only over a portion of the United States. The



annexed maps will tell us the particulars. The full lines in both show the times of the beginning of the occultation, or the immersion, for each ten minutes of central time. The



broken lines show the end or the emersion. The figures on the limit lines indicate the points of tangency of the respective time curves with these limit lines, or in other words denote the places and times at which Mars is seen to graze the moon's limb. It may also be well to note that the occultation of January 1 takes place in the early morning, while that of the 28th is in the evening.

ASTRONOMICAL PHENOMENA IN 1912.

Eclipses.

In the year 1912 there will be four eclipses, two of the sun and two of the moon. The first three will not be of very great importance astronomically since those of the moon are only partial and that of the sun April 17 will have too short a duration of totality to permit of valuable observations. The total eclipse on October 10, will attract more attention since the path of totality passes across South America from Quito to Rio de Janeiro. Doubtless many expeditions will be sent out to observe this eclipse. The duration of totality being nearly two minutes will permit much work of value to be done.

The following data concerning the four eclipses are taken from the *American Ephemeris* for 1912.

I.—*A Partial Eclipse of the Moon*, 1912, April 1, invisible at Washington; the beginning visible generally in Europe, Africa, Asia, except the extreme northeastern portion, central and western Australia, and eastern South America; the ending visible generally in South America except the northwest portion, Europe, Africa, central and western Asia, and western Australia.

Elements of the Eclipse.

Greenwich mean time of ☉ in right ascension, April $1^d\ 9^h\ 19^m\ 53^s.6$

	h	m	s		s
Sun's right ascension	0	43	19.58	Hourly motion	9.10
Moon's right ascension	12	43	19.58	Hourly motion	122.17
	°	′	″	′	″
Sun's declination	4	39	39.5 N	Hourly motion	0 57.8 N
Moon's declination	3	39	4.2 S	Hourly motion	16 20.6 S
Sun's equa. hor. parallax			8.8	Sun's true semidiameter	15 59.8
Moon's equa. hor. parallax		58	21.7	Moon's true semidiameter	15 53.4

Circumstances of the Eclipse.

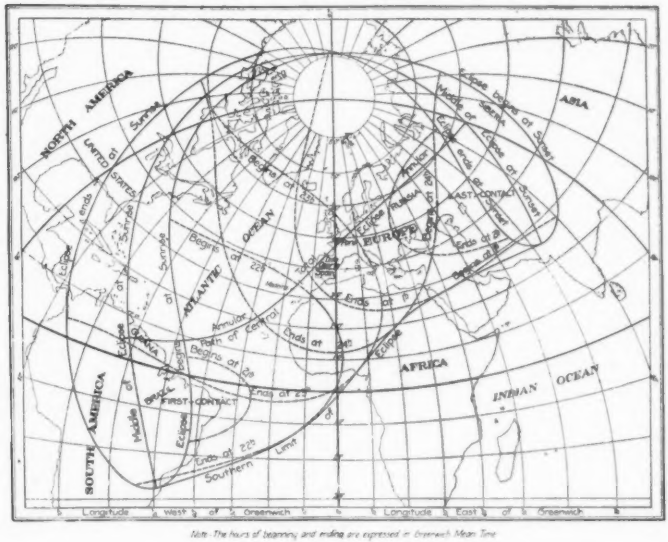
	d	h	m	
Moon enters penumbra	April 1	7	54.4	Greenwich Mean Time.
Moon enters shadow	1	9	25.7	
Middle of the eclipse	1	10	14.0	
Moon leaves shadow	1	11	2.3	
Moon leaves penumbra	1	12	33.7	

Contacts of shadow with Moon's limb	Angles of position from the north point	The Moon being in the zenith in longitude from Greenwich	and in latitude
	°	° ′	° ′
First	177 to W	39 31 E	3 41 S
Last	125 to W	16 7 E	4 7 S

Magnitude of the eclipse = 0.187 (Moon's diameter = 1.0).

II.—*A Central Eclipse of the Sun*, 1911, April 16-17, visible at Washington as a partial eclipse, the sun rising eclipsed. The central eclipse will be total for about thirty-two minutes at the middle of its duration. For the rest of its duration it will be annular.

CENTRAL ECLIPSE OF APRIL 16-17TH 1912.



Note. The hours of beginning and ending are expressed in Greenwich Mean Time

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of δ in right ascension, April 17^d 0^h 3^m 27^s.1

	h	m	s			s	s
Sun and Moon's R. A.	1	40	36.50		Hourly motion	9.27	and 123.43
	°	′	″			′	″
Sun's declination	10	26	51.2	N	Hourly motion	0	52.8 N
Moon's declination	11	0	47.9		Hourly motion	15	0.8
Sun's equa. hor. parallax			8.8		Sun's true semidiameter	15	55.5
Moon's equa. hor. parallax	57		41.4		Moon's true semidiameter	15	42.3

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time	Longitude from Greenwich	Latitude
	d h m	° ′	° ′
Eclipse begins	April 16 20 53.7	42 13.7 W	6 48.2 S
Central eclipse begins	16 22 0.7	61 11.4 W	5 3.5 N
Central eclipse changes from annular to total	16 23 18.9	15 36.2 W	33 50.4 N
Central eclipse changes from total to annular	16 23 58.1	3 9.4 W	45 24.7 N
Central eclipse at local apparent noon	17 0 3.5	0 57.6 W	46 52.9 N
Central eclipse ends	17 1 7.3	89 48.4 E	57 19.8 N
Eclipse ends	17 2 14.3	67 18.6 E	45 52.1 N

III.—*A Partial Eclipse of the Moon*, 1912, September 25-26, the Moon setting at Washington as the eclipse begins; the beginning visible generally in North America except the extreme eastern portion, the Pacific Ocean, eastern Asia, and Australia; the ending visible in central and western North America, the Pacific Ocean, Australia, central and eastern Asia.

ELEMENTS OF THE ECLIPSE.

Greenwich mean time of ☍ in right ascension, September 25^{d} 22^{h} 44^{m} 33^{s}.4

	h m s		s
Sun's right ascension	12 10 52.81	Hourly motion	9.00
Moon's right ascension	0 10 52.81	Hourly motion	108.99
	° ′ ″		′ ″
Sun's declination	1 10 46.3 S	Hourly motion	0 58.5
Moon's declination	0 11 49.8 N	Hourly motion	14 52.3
Sun's equa. hor. parallax	8.8	Sun's trbe semidiameter	15 57.6
Moon's equa. hor. parallax	55 15.8	Moon's true semidiameter	15 2.8

CIRCUMSTANCES OF THE ECLIPSE.

	h h m	
Moon enters penumbra	September 25 21 15.3	Greenwich Mean Time.
Moon enters shadow	25 23 3.1	
Middle of eclipse	25 23 44.7	
Moon leaves shadow	26 0 26.3	
Moon leaves penumbra	26 2 13.7	

Contacts of shadow with Moon's limb	Angles of position from the north point	The Moon being in the zenith in longitude from Greenwich	and in latitude
	°	° ′	° ′
First	8 to W	167 51 W	0 16
Last	50 to W	171 55 E	0 37

Magnitude of the eclipse = 0 122 (Moon's diameter = 1.0).

IV.—*A Total Solar Eclipse of the Sun*, 1912, October 9-10, invisible at Washington.

ELEMENTS OF THE ECLIPSE.

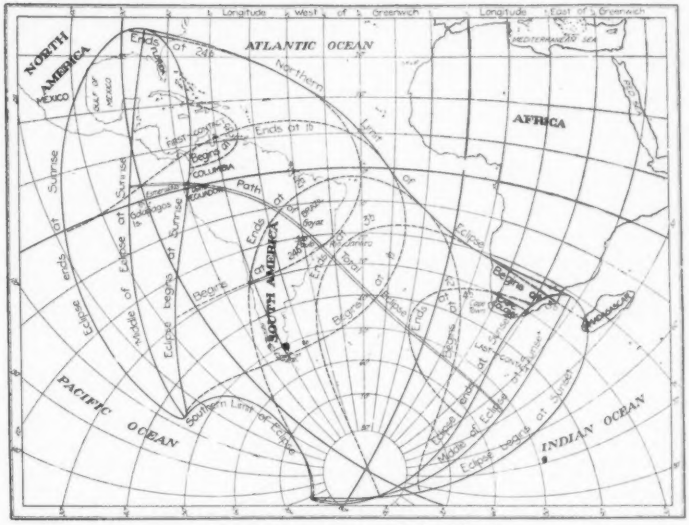
Greenwich mean time of ☌ in right ascension October 10^{d} 1^{h} 59^{m} 47^{s}.8.

	h m s		s s
Sun and Moon's R. A.	13 2 15.76	Hourly motions 9.29 and 127.01	
	° ′ ″		′ ″
Sun's declination	6 38 25.5 S	Hourly motion	0 56.9 S
Moon's declination	7 6 15.2 S	Hourly motion	16 37.2 S
Sun's equa. hor. parallax	8.8	Sun's true semidiameter	16 1.4
Moon's equa. hor. parallax	59 14.7	Moon's true semidiameter	16 7.9

CIRCUMSTANCES OF THE ECLIPSE.

	Greenwich Mean Time			Longitude from Greenwich		Latitude	
	d	h	m	°	′	°	′
Eclipse begins October	9	22	57.0	75	59.2 W	12	39.9 N
Central eclipse begins	9	23	58.7	92	28.6 W	3	43.1 N
Central eclipse at local apparent noon	10	1	59.8	33	11.2 W	34	56.9 S
Central eclipse ends	10	3	13.0	47	14.5 E	52	28.1 S
Eclipse ends.	10	4	14.9	29	25.8 E	43	37.6 S

THE TOTAL ECLIPSE OF OCTOBER 9-10th 1912.



Note.—The hours of beginning and ending are expressed in Greenwich Mean Time.

The regions within which the eclipses of the Sun are visible are laid down on the accompanying charts; from which, by means of the dotted lines, the Greenwich mean times of beginning and ending at any place may be found with an uncertainty which will vary from three or four minutes for a high sun, to fifteen or twenty minutes when the sun is near the horizon.

OCCULTATIONS.

Occultations of stars by the moon are rather frequent phenomena, but are always interesting to the amateur. Observations of these are of value if made with a good telescope and if the times are accurately noted. The correction to the watch or clock employed should be known to the half second by daily comparison with some observatory clock or with the time-signals from some observatory.

A list of 96 occultations which will be visible at Washington during this year is given in the *American Ephemeris* for 1912. The portion of this list for February is given on another page and the remainder will be given in our Planet Notes from month to month.

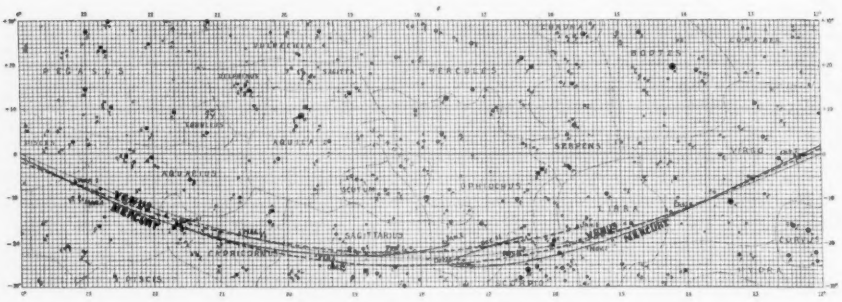


FIGURE 1. APPARENT PATHS OF MERCURY AND THE PLANETS.

The apparent paths of the planets through the zodiacal constellations for the year 1912 are given upon the charts Figures 1 and 2.

Mercury begins the year with a few days retrograde motion in Ophiuchus, then advances through Sagittarius, Capricornus, Aquarius and Pisces until April 5, when it describes a large loop, retrograding until April 27, and then again advancing. During May, June and July the planet advances along the ecliptic through Aries, Taurus, Gemini and Cancer into Leo, where it describes another great loop, dipping down into Sextans then back into Leo. This turn occupies the month of August. During September, October and November the movement is eastward through Leo, Virgo, Libra and Scorpio. Another great turn is made in December in the constellations Ophiuchus and Scorpio, and the planet has again begun its forward movement at the end of the year. The peculiar loops in Mercury's path are because of its rapid movement in its small orbit around the sun, which brings the planet every 116 days between the earth and the sun, where its apparent movement is westward and more rapid than the sun's apparent movement is eastward among the stars.

The following table gives the times when Mercury will be in conjunction with the sun and when it will be at greatest elongation, i. e. farthest out from the sun. The planet will be easiest to observe in the evening during the week preceding March 27 and in the morning about September 7.

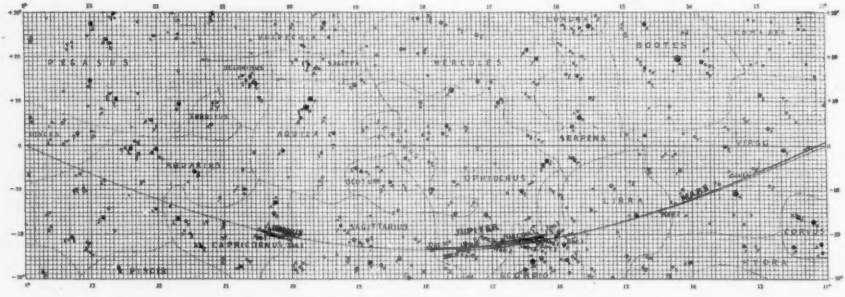
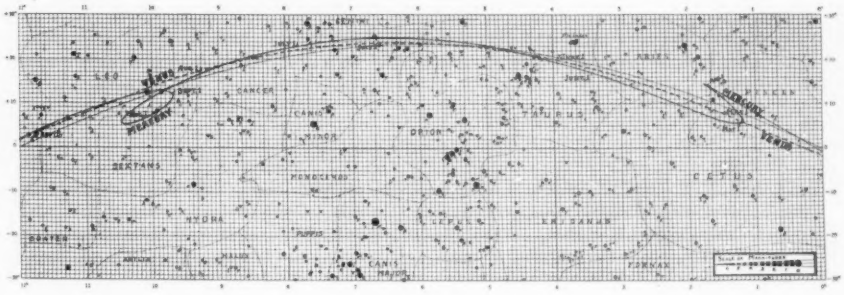


FIGURE 2. APPARENT PATHS OF MARS, JUPITER, SATURN,



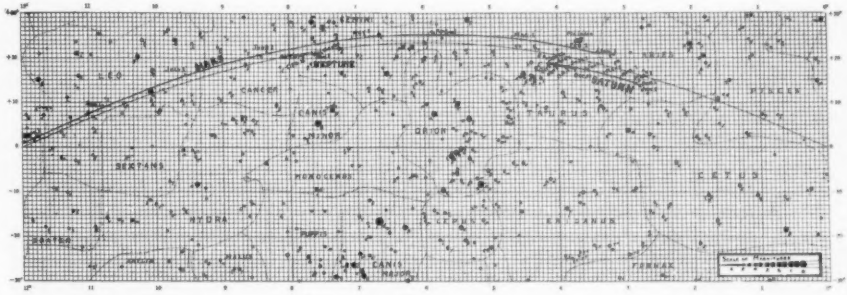
VENUS AMONG THE STARS DURING 1912.

Conjunction		Greatest Elongation		Angle from Sun		Phase	Light
Inferior	Superior	Eastern	Western	°	′		
	Mar. 2	. . .	Jan. 15	23	51	0.60	40
Apr. 15	. . .	Mar. 27	. . .	18	51	0.43	56
. . .	June 16	. . .	May 12	26	03	0.39	32
Aug. 21	. . .	July 25	. . .	27	06	0.46	32
. . .	Oct. 3	. . .	Sept. 7	17	59	0.44	59
Dec. 8	. . .	Nov. 18	. . .	22	15	0.65	44
. . .	. . .	. . .	Dec. 27	22	23	0.62	46

Venus will have no retrograde motion during 1912. Her course starts in Libra and advances through all the zodiacal constellations in turn, and a second time through Libra, Scorpio, Sagittarius and Capricornus. She will be in the vicinity of the sun during a good part of the year, being at superior conjunction July 5.

Mars begins the year in Taurus near the Pleiades and progresses eastward through the year without any retrograde movement. His course passes through Taurus, Gemini, Cancer, Leo, Virgo, Libra and Scorpio, ending in Ophiuchus near Jupiter.

Jupiter's path lies almost wholly in Ophiuchus and Scorpio, the motion being direct during the first three months, retrograde from April 1 to August 2,



URANUS AND NEPTUNE AMONG THE STARS DURING 1912.

and direct during the remainder of the year. Jupiter will be at opposition May 31. The accompanying diagram Fig. 3 shows the orbits of the five inner

FIG 3. APPARENT ORBITS OF THE SATELLITES OF JUPITER AT DATE OF OPPOSITION, JUNE 1, 1912 AS SEEN IN AN INVERTING TELESCOPE.

satellites of Jupiter. The smallest ellipse represents the path of satellite V, which is visible only with very powerful telescopes.

Saturn's course passes from Aries into Taurus, the movement being eastward until September 16 and retrograde for the remainder of the year. The rings of Saturn this year are turned well open to view, the elevation of the earth above the plane of the rings being —25° in the latter part of the year.

Uranus describes only a short circuit in Sagittarius and Capricornus, moving eastward until May 8, then westward until October 10, then eastward for the remainder of the year. Uranus may be easily picked up with a small telescope but is not visible to the naked eye.

Neptune's course is a very short one, in the eastern part of the constellation Gemini. The movement is slow retrograde until May 10, then direct until October 10 and after that retrograde again. Neptune is easily visible with a small telescope but cannot be distinguished from a star by its appearance. One must chart the stars in the vicinity and detect the planet by its motion from night to night.

THE COMETS.

Of the periodic comets to return to perihelion in 1912, the only one sure to be observed is *Wolf's*, which has already been sighted and is reckoned as comet *d* 1911. It will not reach perihelion until some time in February.

Borrelly's comet 1905 II also is being observed now, its period having been shortened by the perturbations of the planets, so that it passed perihelion in December 1911 instead of in March 1912.

Barnard's comet 1892 V would be due at perihelion in the middle of the summer, according to the elements given in POPULAR ASTRONOMY, Vol. XIV, p. 223, but as it was not seen at the more favorable return in the winter of 1905-6 it is not likely to be recovered this year.

This is the year for the return of *Biela's* comet, provided the orbit has remained unchanged, and there is the possibility that the earth may encounter some of the fragments of the lost comet when we cross its path about Nov. 23.

Holmes' comet is due at perihelion on its third return early in 1913 but is more likely to be observed in the summer of 1912, if it becomes visible at all.

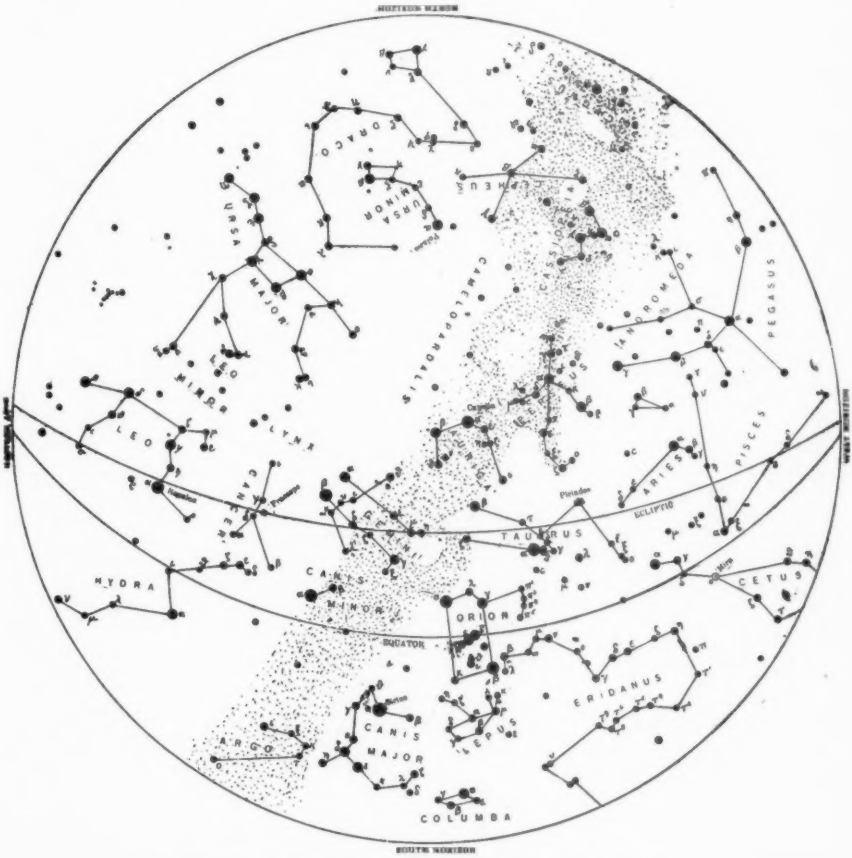
Besides the periodic comets, several of the new comets of 1911 will remain visible through a part of this year, notably Brook's *c*, Quenisset's *f* and Schaumasse's *h* 1911.

VARIABLE STARS.

The number of variable stars of the Algol type now on our list is 86, and of those of short period not of the Algol type 100. We have been obliged to reduce the number of computations of the times of maxima and minima to one a week for each star, where the period is less than a week. The computations have been carried out to the nearest minute of time, but in the tables which we publish each month only the nearest hour is given, so that the observer need not be influenced to make his observations fit the calculations.

We shall be glad to receive corrections to the elements of these variables at any time and to be notified of any errors found in our tables.

The table of approximate magnitudes of long period variables will be prepared as heretofore at Harvard College Observatory.



THE CONSTELLATIONS AT 9:00 P. M. FEBRUARY 1, 1912.

Meteors.

Meteors may be observed on any clear night and observations are of value which consist in merely counting the meteors which are seen in a given time in a given area of the sky. Still more valuable observations consist in plotting carefully upon a planisphere star map the trails of meteors and recording the brightness and the exact times of the beginning and end of the apparition.

The following is a list of the most brilliant meteoric showers which recur year after year. It is taken from Mr. W. F. Denning's more extended list in the *Companion to the Observatory* for 1911.

Date	Radiant α	Radiant δ	Meteors
Jan. 2—3	230°	+53°	Swift; long paths
Apr. 20—22	271	+33	Swift
May 1—6	338	− 2	Swift; streaks
July 28	339	−11	Slow; long
Aug. 10—12	45	+57	Swift; streaks
Oct. 18—20	92	+15	Swift; streaks
Nov. 14—16	150	+22	Swift; streaks
Nov. 17—23	25	+43	Very slow; trains
Dec. 10—12	108	+33	Swift; short.

The Perseids, with maximum on August 11, are visible for a considerable period and their radiant point exhibits a motion to E. N. E. among the stars. The following is an ephemeris:—

Date	Radiant α °	Radiant δ °	Date	Radiant α °	Radiant δ °	Date	Radiant α °	Radiant δ °
July 19	18.9	+50.5	July 29	29.3	+53.8	Aug. 8	41.5	+56.5
21	20.8	+51.1	31	31.6	+54.4	10	44.3	+56.9
23	22.8	+51.8	Aug. 22	33.9	+55.0	12	47.1	+57.3
25	24.9	+52.5	4	36.4	+55.5	14	50.0	+57.7
27	27.1	+53.2	6	38.9	+56.0	16	52.9	+58.0

Phases of the Moon.

1912 Washington Mean Time.

New Moon d h m	First Quarter d h m	Full Moon d h m	Last Quarter d h m
		Jan. 3 19 29.7	Jan. 10 13 42.9
Jan. 18 17 10.0	Jan. 26 14 51.4	Feb. 2 5 58.0	Feb. 9 6 50.8
Feb. 17 11 44.2	Feb. 25 1 26.7	Mar. 2 16 42.0	Mar. 10 1 55.6
Mar. 18 4 08.7	Mar. 25 9 01.9	Apr. 1 4 04.5	Apr. 8 21 23.8
Apr. 16 17 40.1	Apr. 23 14 47.2	Apr. 30 16 19.4	May 8 15 56.0
May 16 4 13.5	May 22 20 11.3	May 30 5 29.5	June 7 8 35.6
June 14 12 23.6	June 21 2 38.9	June 28 19 33.8	July 6 22 46.9
July 13 19 13.2	July 20 11 18.5	July 28 10 28.2	Aug. 5 10 17.6
Aug. 12 1 57.6	Aug. 18 22 56.6	Aug. 27 1 58.8	Sept. 3 19 23.1
Sept. 10 9 48.5	Sept. 17 13 54.8	Sept. 25 17 34.2	Oct. 3 2 48.1
Oct. 9 19 40.6	Oct. 17 8 06.2	Oct. 25 8 30.5	Nov. 1 9 37.5
Nov. 8 8 04.8	Nov. 16 4 43.3	Nov. 23 22 12.2	Nov. 30 17 04.8
Dec. 7 23 06.6	Dec. 16 2 06.5	Dec. 23 10 30.1	Dec. 30 2 11.9

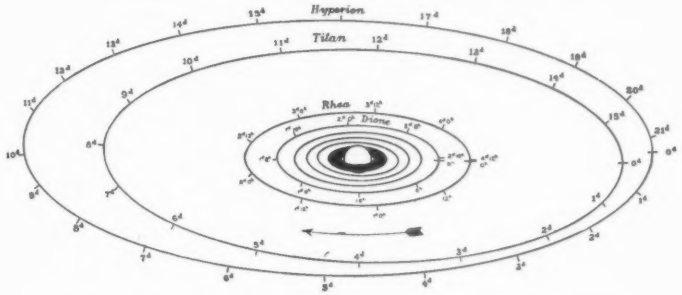
Occultations visible at Washington.

Date 1912	Star's Name	Magnitude.	IMMERSION. Washington M.T. h m	IMMERSION. Angle f'm N. °	EMERSION. Washington M.T. h m	EMERSION. Angle f'm N °	Duration h m
Feb. 4	308 B Leonis	5.8	8 54	141	9 48	272	0 54
5	13 Virginis	5.9	17 50	89	18 45	342	0 55
10	σ Scorpii	3.1	14 35	130	15 42	281	1 07
12	C.D. −28°14268	6.4	16 58	118	18 13	264	1 15
26	107 B Aurigæ	6.5	8 19	83	9 37	273	1 18
27	49 Aurigae	5.1	4 55	58	6 01	290	1 06
28	4 Cancri	6.2	15 01	94	15 50	305	0 49

Saturn's Satellites.

CENTRAL STANDARD TIME.

E = eastern elongation; W = western elongation.
I = inferior conjunction; S = superior conjunction.



APPARENT ORBITS OF THE SEVEN INNER SATELLITES OF SATURN,
at date of opposition, November 23, 1912, as seen in an inverting telescope.

I. Mimas. Period 0d 22h.6.

Feb. 3	10.8 W	Feb. 5	8.1 W	Feb. 12	9.8 E	Feb. 14	7.0 E
4	9.3 W	6	6.7 W	13	8.4 E	15	5.6 E

II. Enceladus. Period 1d 8h.9.

Feb. 1	10.1 E	Feb. 8	6.6 E	Feb. 15	3.1 E	Feb. 21	23.6 E
2	19.0 E	9	15.5 E	16	12.0 E	23	8.5 E
4	3.9 E	11	0.4 E	17	20.9 E	24	17.4 E
5	12.8 E	12	9.3 E	19	5.8 E	26	2.4 E
6	21.7 E	13	18.2 E	20	14.7 E	27	11.2 E

III. Tethys. Period 1d 21h.3.

Feb. 1	4.8 E	Feb. 8	18.1 E	Feb. 16	7.3 E	Feb. 23	20.7 E
3	2.1 E	10	15.4 E	18	4.7 E	25	18.0 E
4	23.4 E	12	12.7 E	20	2.0 E	27	15.3 E
6	20.7 E	14	10.0 E	21	23.3 E	29	12.7 E

IV. Dione. Period 2d 17h.7.

Feb. 3	17.9 E	Feb. 9	4.7 E	Feb. 14	16.2 E	Feb. 22	21.3 E
6	11.0 E	11	22.4 E	17	9.9 E	25	15.1 E
				20	3.6 E	28	8.8 E

V. Rhea. Period $4^d\ 12^h.5$.

Feb. 5	6.9 E	Feb. 14	7.9 E	Feb. 23	8.9 E	Feb. 27	21.4 E
9	19.4 E	18	20.5 E				

VI. Titan. Period $15^d\ 23^h.3$.

Feb. 1	13.6 I	Feb. 9	6.9 S	Feb. 17	12.9 I	Feb. 25	6.2 S
5	9.7 W	13	10.7 E	21	9.0 W	29	10.0 E

VII. Hyperion. Period $21^d\ 7^h.6$.

Feb. 4.0 S	Feb. 9.5 E	Feb. 14.5 I	Feb. 19.6W	25.3 E

VIII. Iapetus. Period $79^d\ 22^h.1$.

Feb. 4.4 W	Feb. 23.8S		

IX. Phoebe. Period $580^d\ 4^h.7$.

	α Ph.—α Sat	δ Ph.—δ Sat.		α Ph.—α Sat.	δ Ph.—δ Sat.
	m s	′		m s	′
Feb. 5	−1 30.8	−8.6	Feb. 20	−1 37.7	−9.3
10	−1 33.6	−8.9	25	−1 39.0	−9.5
15	−1 35.9	−9.1	Mar. 1	−1 39.8	−9.6

VARIABLE STARS.

New Variable 46.1911 Tauri.—This star is BD + 23°555 ($9^m.4$) and is within the Pleiades group. Mr. G. A. Tikhoff in the *Comptes Rendus*, Tome 153 p. 653, gives the following provisional elements:

Maximum = 1911 Jan. 10 + 565^d E.

The star is red and its photographic brightness ranges from 10.8 to 11.5 magnitude.

New Variables 47 and 48.1911:—In *A. N.* 4538 Professor W. Ceraski announces two new variable stars discovered by Mme. L. Ceraski at Moscow. The first is BD + 29° 2690 ($9^m.4$), the second an anonymous star. The positions are:

	α 1855.0	δ 1855.0	α 1900.0	δ 1900.0
	h m s	° ′	h m s	° ′
47.1911 Coronæ bor.	15 33 05.7	+ 29 56.7	15 33 56.3	+29 47.7
48.1911 Pegasi	21 19 58	+ 15 57	21 22 05	+16 09

The first varies between magnitudes 9.2 and 9.7, the second between 10.5 and 12.5. The periods are unknown.

Variation of α Orionis.—About four months ago I called the attention of those in charge (you were at Lick Observatory then) of POPULAR ASTRONOMY to a well defined minimum of α Orionis. At that time they did not think it worth while to mention it. Now for nearly two years I have given α Orionis much attention. According to my observations with naked eye and very small telescope, a well marked minimum took place February 17, 1911, α being $\frac{4}{10}$ of a magnitude below normal. The observations of February 1911 were made

at Seabreeze, Florida, the remainder at Providence. Professor Wendell of Harvard Observatory confirms my observations. From February 14 to February 21, Betelgeuse was only $\frac{1}{10}$ magnitude brighter than Aldebaran, the faintest I ever saw it. There was a well marked maximum October 14 to October 20, 1902. At that time it was a little superior to Capella. The conditions for observing at Seabreeze, Florida are excellent. Imagine going out and looking at Orion in a clear dark sky in your shirtsleeves, and without a hat on. The zodiacal light was the most brilliant that I ever saw it. The "seeing" seemed to be very good.

F. E. SEAGRAVE.

PROVIDENCE, JULY 22, 1911.

The above note should have appeared in the August 1911 number of POPULAR ASTRONOMY, but was misplaced. [ED.]

Thirty-one New Variable Stars.—In the Harvard Circular 167 thirty-one new variable stars are announced by Professor Pickering as having been discovered, upon the photographs of the Henry Draper Memorial, by the late Mrs. Fleming and other observers. There is also given a list of seven other objects having peculiar spectra.

Constellation	DM.		R.A.1900		Dec. 1900		Bright	Faint	Range	Spect.	Discoverer
			h	m	°	′					
Phoenix	−56°	277	1	15.9	−56	26	8.5	16.0	7.5	Md	Fleming
Perseus	+38°	525	2	32.1	+38	44	11.0	<14.0	>3.0	N	Cannon
Triangulum	+30°	428	2	35.0	+30	47	10.0	11 5	1.5	Mc5	Leland
Perseus	+33°	490	2	35.4	+34	5	8.5	9.1	0.6	Mc5	Fleming
Fornax	. .		3	40.3	−25	32	9.8	<13.0	>3.2	. .	Mackie
Caelum	−36°	1884	4	43.8	−36	23	8.7	10 3	1.6	N	Fleming
Auriga	+32°	957	5	15.3	+32	24	9.2	10.6	1.4	Md	Fleming
Pictor	−46°	1969	5	40.4	−46	30	11.0	<15 0	>4.0	N	Wells
Auriga	+41°	1556	6	50.3	+41	14	9.6	12.6	3.0	N	Fleming
Monoceros	− 7°	1742	7	2.1	− 7	24	12.8	14.0	1.2	. .	Wells
Vela	−41°	5381	9	46.0	−41	34	9.2	10.5	1.3	Mc5	Fleming
Crater	−19°	3254	11	18.9	−19	22	9.2	10.2	1.0	Mc5	Fleming
Centaurus	−44°	8539	13	10.7	−44	10	9.0	9 6	0.6	Pec.	Fleming
Sagittarius	. .		18	10.7	−21	36	11 8	<15.0	>3.2	. .	Breslin
Sagittarius	. .		18	22.3	−16	50	10.9	<15.0	>4.1	Md	Fleming
Ophiuchus	+ 4°	3779	18	26.4	+ 4	19	14·0	15.0	1.0	N	Wells
Coron. Astr.	−42°	13488	18	32.9	−42	41	12.2	15.5	3.3	. .	Mackie
Aquila	+ 0°	4064	18	52.5	+ 0	10	9.6	11.0	1.4	. .	Wells
Aquila	+14°	3729	18	54.0	+14	14	9.6	11.6	2.0	. .	Wells
Sagittarius	. .		19	11.9	−17	39	10.0	14.0	4.0	. .	Mackie
Sagittarius	−32°	15116	19	16.3	−32	19	10.3	14.0	3.7	. .	Mackie
Sagittarius	. .		19	21.2	−18	43	9.4	15.0	5.6	Md	Fleming
Sagitta	+20°	4417	20	0.7	+20	22	10.0	12.0	2.0	N	Wells
Cygnus	+37°	3903	20	17.9	+37	13	11.5	12.5	1 0	. .	Wells
Indus	−47°	13487	20	32.2	−46	57	10.3	11.1	0.8	Md?	Fleming
Microscop	. .		20	58.4	−33	40	9.3	<15.0	>5.7	Md	Fleming
Pegasus	. .		21	4.3	+15	38	10.1	<14.0	>3.9	Md	Cannon
Grus	−45°	14361	21	25.3	−45	29	9.8	14.0	4.2	. .	Mackie
Piscis Austr.	−30°	19355	22	49.8	−30	9	8.4	9.7	1.3	Mc5	Fleming
Andromeda	+45°	4121	22	57.2	+45	21	11.5	12.2	0.7	. .	Wells
Cassiopeia	+60°	2634	23	48.0	+60	27	11.0	11.0	0.7	Mc	Wells

Approximate Magnitudes of Variable Stars on Dec. 1, 1911.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R.A. 1900. h	m	Decl. 1900. °	′	Magn
X Androm.	0	10.8	+46	27	12.8	T Urs. Maj.	12	31.8	+60	2	<12
T Androm.		17.2	+26	26	9.3 *i*	RS Urs. Maj.		34.4	+59	2	12.4*d*
T Cassiop.		17.8	+55	14	11.6*d*	S Urs. Maj.		39.6	+61	38	9.0*d*
R Androm.		18.8	+38	1	8.2 *i*	T Urs.Min.	13	32.6	+73	56	<11
S Ceti		19.0	− 9	53	<11	U Urs. Min.	14	15.1	+67	15	11.2
Y Cephei		31.3	+79	48	<13	S Boötis		19.5	+54	16	9.7 *i*
U Cassiop.		40.8	+47	43	11.5 *i*	R Camelop.		25.1	+84	17	9.0
RW Androm.		41.9	+32	8	10.3 *i*	S Coronae	15	17.3	+31	44	12.0
V Androm.		44.6	+35	6	11.3*d*	R Cor. Bor.		44.4	+28	28	7.7
RR Androm.		45.9	+33	50	<11	X Cor. Bor.		45.2	+36	35	9.0
RV Cassiop.		47.1	+46	53	14.2 *i*	V Cor. Bor.		46.0	+39	52	10.7 *i*
W Cassiop.		49.0	+58	1	9.1 *i*	W Cor.Bor.	16	11.8	+38	3	10.2 *i*
U Androm.	1	9.8	+40	11	13.2	U Herculis		21.4	+19	7	9.1 *i*
— Androm.		10.4	+41	12	13.7	W Herculis		31.7	+37	32	11.0*d*
S Cassiop.		12.3	+72	5	9.0*d*	R Draconis		32.4	+66	58	12.0
S Piscium		12.4	+ 8	24	<13	S Herculis		47.4	+15	7	10.2
RZ Persei		23.6	+50	20	12.1*d*	RV Herculis		56.8	+31	22	13.5 *i*
R Piscium		25.5	+ 2	22	<12	RS Herculis	17	17.5	+23	1	11.5*d*
RU Androm.		32.8	+38	10	10.3 *i*	T Draconis		54.8	+58	14	11.0
Y Androm.		33.7	+38	50	13.0 *i*	V Draconis		56.3	+54	53	11.6
X Cassiop.		49.8	+58	46	<13	W Draconis	18	5.4	+65	56	10 3
R Arietis	2	10.4	+24	35	13.8	T Herculis		5.3	+31	0	9.3 *i*
W Androm.		11.2	+43	50	8.0	X Draconis		6.8	+66	8	11.3*d*
Z Cephei		12.8	+81	13	<13	W Lyrae		11.5	+36	38	8.7*d*
o Ceti		14.3	− 3	26	9.1	SV Draconis		31.2	+49	18	10.2 *i*
S Persei		15.7	+58	8	<11	RY Lyrae		41.2	+34	34	14.0
RR Persei		21.7	+50	49	14.3	R Scuti		42.2	− 5	49	5.6*d*
RR Cephei		29.4	+80	42	10.5 *i*	Z Lyrae		56.0	+34	49	13.3
W Persei		43.2	+56	34	9.7*d*	V Lyrae	19	5.2	+29	30	<13
U Arietis	3	5.5	+14	25	12.6	S Lyrae		9.1	+25	50	14.3*d*
X Ceti		14.3	− 1	26	10.5 *i*	U Draconis		9.9	+67	7	9.5
Y Persei		20.9	+43	50	10.6 *i*	W Aquilae		10.0	− 7	13	12.5
R Persei		23.7	+35	20	11.6*d*	TY Cygni		13.4	+50	0	11.0*d*
W Tauri	4	22.2	+15	49	9 6*d*	U Lyrae		16.6	+37	42	11.2*d*
R Tauri		22.8	+ 9	56	11.5 *i*	TZ Cygni		29.8	+28	6	<12
S Tauri		23.7	+ 9	44	<13	R Cygni		34.1	+49	58	6.0
T Camelop.		30.4	+65	57	12.0 *i*	TU Cygni		43.3	+48	49	12.5
X Camelop.		32.6	+74	56	9.0	X Cygni		46.7	+32	40	9.5*d*
V Orionis	5	0.8	+ 3	58	11.1*d*	Z Cygni		58.6	+49	46	12.7
S Aurigae		20.5	+34	4	8.6	S Aquilae	20	7.0	+15	19	9.7
W Aurigae		20.1	+36	49	10.7*d*	RS Cygni		9.8	+38	28	8 3
S Camelop.		30.2	+68	45	8.5	R Sagittae		9.5	+16	25	8.6
U Aurigae		35.6	+31	59	<12	R Delphini		10.1	+ 8	47	<11
SU Tauri		43.2	+19	2	10.5	SX Cygni		11.6	+30	46	11.0 *i*
Z Tauri		46.7	+15	46	<13	V Sagittae		15.8	+20	47	11.5
V Camelop.		49.4	+74	30	10.1*d*	U Cygni		16.5	+47	37	7.7 *i*
U Orionis		49.9	+20	10	<11	ST Cygni		29.9	+54	38	12.5 *i*
Z Aurigae		53.6	+53	18	9.4 *i*	Y Delphini		36.9	+11	31	12.0
V Monoc.		17.7	− 2	9	12.9	S Delphini		38.5	+16	44	11.2*d*
U Lyncis		31.8	+59	57	9.6	Y Aquarii		39.2	− 5	12	<14
S Lyncis		35.9	+58	0	9.1	T Delphini		40.7	+16	2	12.3 *i*
R Lyncis		53.0	+55	28	9.3 *i*	T Aquarii		44.7	− 5	31	9.1*d*
V Can. Min.	7	1.5	+ 9	2	8.7	RZ Cygni		48.5	+46	59	13.2
RR Monoc.		12.4	+ 1	17	10.6 *i*	R Vulpeculae		59.9	+23	26	10.1
U Gemin.		49.2	+22	16		TW Cygni	21	1.8	+29	0	11.0
Y Draconis	9	31.1	+78	18	11.5	X Cephei		3.6	+82	40	<13
R Urs. Maj.	10	37.6	+69	18	9.1	R Equulei		8.4	+12	23	<14

Approximate Magnitudes of Variable Stars on Dec. 1, 1911.

Continued.

Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.	Name.	R. A. 1900. h	m	Decl. 1900. °	′	Magn.
T Cephei	21	8.2	+68	5	8.7*d*	RW Pegasi	22	59.2	+14	46	9.7
S Cephei		36.5	+78	10	9.8 *i*	R Pegasi	23	1.6	+10	0	9.7*d*
V Pegasi		56.0	+ 5	38	10.0 *i*	V Cassiop.		7.4	+59	8	9.8 *i*
T Pegasi	22	4.0	+12	3	13.5 *i*	ST Androm.		33.8	+35	13	8.9
Y Pegasi		6.8	+13	52	<14	R Aquarii		38.6	−15	50	10.3*d*
RS Pegasi		7.4	+14	4	12.7	Z Cassiop.		39.7	+56	2	<13
X Aquarii		13.2	−21	24	9.0	R Cassiop.		53.3	+50	50	11.3
S Lacertae		24.6	+39	48	10.3*d*	Y Cassiop.		58.2	+55	7	11.8
R Lacertae		38.8	+41	51	9.9*d*	SV Androm.		59.2	+39	33	<12

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude. The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:— W. N. Bixby, C. E. Furness, Edward Gray, W. P. Hoge, C. J. Hudson, S. C. Hunter, M. W. Jacobs, Jr., W. T. Olcott, P. R. Sutton, H. M. Swartz, David Todd, H. W. Vrooman, and A. S. Young.

Minima of Variable Stars of the Algol Type.

[Calculated by Mary H. Wilson at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h, etc.

Star	R. A. 1900 h	m	Decl. 1900 °	′	Magnitude	Approx. Period d	h	Greenwich mean times of minima in **February** 1912. d h	d h	d h	d h
SY Androm.	0	08.0	+43	09	9.5—13.0	34	21.6	4 05			
UU Androm.		38.5	+30	24	10.7—11.9	1	11.7	1 17;	7 15;	13 14;	19 13
U Cephei	0	53.4	+81	20	7.1— 9.2	2	11.8	4 08;	14 07;	19 07;	24 07
Z Persei	2	33.7	+41	46	9.4—12.	3	01.4	6 01;	12 04;	18 06;	24 09
RY Persei		39.0	+47	43	8.0—10.3	6	20.7	5 10;	12 07;	19 04;	26 00
RZ Cassiop.		39.9	+69	13	6.4— 7.8	1	04.7	3 09;	9 08;	15 08;	27 07
ST Persei		53.7	+38	47	8.5—10.5	2	15.6	2 17;	8 00;	18 14;	29 05
RX Cephei	2	58.8	+67	11	8.6— 9.1	32	07.6		17 02		
Algol	3	01.7	+40	34	2.3— 3.5	2	20.8	4 06;	10 00;	15 17;	27 04
RT Persei		16.7	+46	12	9. —11.	0	20.4	6 01;	11 03;	16 05;	26 10
λ Tauri		55.1	+12	12	3.4— 4.5	3	22.9	2 10;	10 08;	18 05;	26 03
RW Tauri	3	57.8	+27	51	7.1—<11	2	18.5	5 10;	10 23;	16 12;	22 01
RV Persei	4	04.2	+33	59	10.6—12.8	1	23.4	5 16;	11 14;	17 12;	23 10
RW Persei		13.3	+42	04	8.8—11.0	13	04.8	4 08;	17 13		
RS Cephei	4	48.6	+80	06	9.5—12.2	12	10.1	5 04;	17 14		
RY Aurigæ	5	11.5	+38	13	10.7—11.7	2	17.5	3 18;	9 05;	14 15;	25 14
RZ Aurigæ		42.9	+31	40	10.6—13.3	3	00.3	4 08;	10 08;	16 09;	22 09
SV Gemin;		54.6	+24	28	9.8—<11	4	00.2	6 20;	14 20;	22 20	
RW Gemin.	5	55.4	+23	08	9.5—11.0	2	20.8	1 13;	7 07;	13 00;	24 11
U Columbæ	6	11.2	−33	03	9.4—10.2	2	19.2	3 15;	9 05;	14 19;	26 00
56.1908 Gem.		22.	+20	37	10.8—11.5	1	08.8	2 21;	8 08;	13 20;	24 18
RW Monoc.		29.3	+ 8	54	9.0—10.8	1	21.7	1 06;	8 21;	16 12;	24 03
RX Gemin.		43.6	+33	21	8.8— 9.6	12	05.0	2 00;	14 05;	26 10	
RU Monoc.	6	49.4	− 7	28	9.8—10.5	0	21.5	3 10;	8 19;	14 4;	22 13

Minima of Variable Stars of the Algol Type.—Continued.

Star	R. A. 1000 h	m	Decl. 1900 °	′	Magnitude	Approx Period d	h	Greenwich mean times of maxima in **February** 1912. d h	d h	d h	d h
R Canis Maj.	7	14.9	−16	12	5.9— 6.7	1	03.3	6 13;	12 22;	17 05;	23 14
RY Gemin.		21.7	+15	52	8.9—<10	9	07.2	5 07;	14 14;	23 22	
Y Camelop		27.6	+76	17	9.5—12.	3	07.3	7 01;	13 15;	20 06;	26 21
RR Puppis		43.5	−41	08	9.5—	6	10.3	6 09;	12 19;	19 05;	25 16
V Puppis	7	55.4	−48	58	4. — 5.	1	10.9	2 13;	9 20;	17 02;	24 09
X Carinæ	8	29.1	−58	53	7.8— 8.9	0	13.0	5 06;	10 16;	16 02;	21 12
S Cancri	8	38.2	+19	24	8. —10.	9	11.6	5 16;	15 03;	24 15	
S Velorum	9	29.5	−44	46	7.8— 9.5	5	22.4	2 18;	8 16;	14 15;	20 13
Y Leonis	9	31.1	+26	41	9.3—11.2	1	16.5	4 03;	12 14;	21 00;	29 10
RR Velorum	10	17.8	−41	36	10.0—10.9	1	20.5	1 21;	11 04;	20 10;	29 17
SS Carinæ	10	54.2	−61	23	12.2—12.8	3	07.2	1 22;	8 13;	15 03;	28 08
RW Urs. Maj	11	35.4	+52	34	9.3—10.3	7	07.9	1 09;	8 17;	16 01;	23 09
Z Draconis	11	40.6	+72	49	9.5—12.5	1	08.6	2 05;	9 00;	15 18;	22 13
SS Centauri	13	07.2	−63	37	8.8—10.4	2	11.5	1 08;	8 18;	16 05;	23 15
δ Libræ	14	55.6	−	8 07	5. — 6.7	2	07.9	5 03;	12 03;	19 02;	26 02
U Coronæ	15	14.1	+32	01	7.8— 9.0	3	10.9	7 17;	14 15;	21 13;	28 11
TW Draconis	15	32.4	+64	14	7.0— 8.9	2	19.4	3 21;	12 08;	20 18;	29 04
SW Ophiuchi	16	11.1	−	6 44	9.2—10.	2	10.7	7 14;	14 22;	22 06;	29 14
SX Ophiuchi	16	12.6	−	6 25	10.5—11.2	2	01.5	2 03;	8 07;	20 16;	26 21
R Aræ	16	31.1	−56	48	6.7— 8.	4	10.2	8 13;	17 10;	26 06	
TT Herculis	16	49.9	+17	00	8.9— 9.5	20	18.1	6 23;	27 17;		
TU Herculis	17	09.8	+30	50	9.5—12.	2	06.4	6 01;	12 20;	19 15;	26 10
U Ophiuchi		11.5	+	1 19	6. — 6.7	0	20.1	4 09;	12 18;	21 03;	29 13
SZ Herculis	17	36.0	+33	01	9 5—10.3	0	19.6	3 01;	11 05;	19 09;	27 14
Z Herculis	17	53.6	+15	09	6.7— 8.0	3	23.8	1 20;	9 20;	17 19;	25 19
SX Draconis	18	03.0	+58	23	9.3—10.5	5	04.1	5 03;	10 07;	15 11;	20 15
RS Sagittarii		11.0	−34	08	6.7— 7.8	2	10.0	1 03;	8 09;	15 15;	22 21
V Serpentis		11.1	−15	34	9 5—	3	10.9	1 22;	8 23;	15 17;	22 15
RZ Draconis		21.8	+58	50	9.5—10.2	0	13.2	4 04;	9 16;	15 04;	26 05
RX Herculis		26.0	+12	32	7.8— 8.0	0	21.3	6 20;	15 17;	24 15	
SX Sagittarii		39.7	−30	36	8.6— 9.4	2	01.8	2 11;	8 16;	14 22;	27 09
RR Draconis		40.8	+62	34	9.3—13.	2	19.9	5 18;	14 06;	22 18	
RS Scuti		43.7	−10	21	9.3—10.3	0	15.9	3 14;	10 05;	16 19;	23 10
U Scuti	18	48.9	−12	44	9.0— 9.8	0	22.9	9 21;	19 10;	28 23	
RX Draconis	19	01.1	+58	35	9.3—10.2	1	21.5	1 07;	10 18;	20 05;	29 17
RV Lyræ		12.5	+32	15	11. —13.	3	14.4	4 04;	11 08;	18 13;	25 19
RS Vulpec.		13.4	+22	16	6.9— 8.0	4	11.4	9 07;	18 06;	27 05	
U Sagittæ		14.4	+19	26	6.7— 9.0	3	09.1	3 00;	9 18;	16 12;	23 06
Z Vulpec.		17.5	+25	23	7.3— 8.5	2	10.9	3 15;	11 00;	18 09;	25 18
136.1910 Lyræ		24.3	+41	30	9.0<11.0	5	05.8	1 04;	6 10;	16 22;	27 10
SY Cygni	19	42.7	+32	28	10. —12.	6	00.2	4 19;	10 19;	16 19;	28 19
WW Cygni	20	00.6	+41	18	9.5—12.5	3	07.6	3 10;	10 01;	16 16;	23 08
SW Cygni		03.8	+46	01	9. —12.	4	13.8	9 07;	18 10;	27 14	
VW Cygni		11.4	+34	12	9.5—11.5	8	10.3	1 05;	9 15;	18 01;	26 12
RW Capric.		12.2	−17	59	8.8—10.6	3	09.4	6 04;	12 23;	19 18;	26 13
UW Cygni		19.6	+42	55	10.5—13.	3	10.8	5 05;	12 03;	19 01;	25 22
W Delphini		33.1	+17	56	9.5—11.5	4	19.4	9 19;	19 10;	29 00	
RR Delphini		38.9	+13	35	10.5—11.8	4	14.4	1 10;	10 15;	19 19;	29 00
Y Cygni		48.1	+34	17	7. — 8.	1	12.0	1 04;	8 16;	16 04;	23 15
RR Vulpec.	20	50.5	+27	32	9.6—11.0	5	01.2	5 19;	10 20;	15 22;	26 00
VV Cygni	21	02.3	+45	23	11. —14.	1	11.4	1 11;	8 20;	16 05;	23 15
AE Cygni		09.0	+30	20	10.8—11.4	0	23.3	2 20;	12 12;	22 05	
UZ Cygni		55.2	+43	52	9. —11.5	31	07.3	4 13			
RT Lacertæ	21	57.4	+43	24	9.1—10.5	5	01.7	4 03;	9 05;	19 08;	29 12
RW Lacertae	22	40.6	+49	08	10.2—11.2	5	04.4	2 03;	7 07;	17 16;	28 03
TT Androm	23	08.7	+45	36	10.5—11.3	2	18.3	5 04;	13 11;	21 18;	
32.1911 Pisc.		29.3	+	7 22	9.0—12.0	3	18.4	3 05;	10 18;	18 07;	25 19
TW Androm.	23	58.2	+32	17	8.6—11.5	4	02.9	4 04;	12 10;	20 16;	28 23

Maxima of Variable Stars of Short Period not of the Algol Type.

[Calculated by Wallace F. Johnson at Goodsell Observatory]

Given to the nearest hour in Greenwich mean time. To obtain eastern standard time subtract 5^h; Central standard time 6^h etc. An * following the name of a star signifies that for that star times of minima instead of maxima are given.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in **February** 1912.
	h m	° ′		d h	d h d h d h d h
SX Cassiop.	0 05.5	+54 20	8.6— 9·4	36 13.7	14 15
SY Cassiop.	9.8	+57 52	9 3— 9.9	4 1.7	8 23; 17 02; 25 06
RT Sculptor.*	0 31.5	−26 13	9.6—10.5	0 12.3	2 07; 7 10; 17 16; 27 21
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	4 01; 9 13; 15 02; 26 04
RW Cassiop.	1 30.7	+57 15	8.6— 9.4	14 19 2	13 07; 28 02
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	5 06; 11 05; 17 04; 23 03
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	4 01; 9 21; 15 18; 27 10
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	5 00; 11 01; 17 03; 23 05
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	8 00; 24 00
SX Persei	4 10.2	+41 29	10.3—11.0	4 07.1	8 11; 17 01; 25 15
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	11 06; 22 09
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	10 07; 21 22
TT Aurigæ*	5 02.8	+39 27	7.8— 8.7	0 16.0	6 02; 12 18; 19 10; 26 01
SX Aurigæ	04.6	+42 02	8.0— 8.7	1 12.8	7 03; 13 06; 19 09; 25 12
SY Aurigæ	05.5	+42 42	9.0— 9.7	10 03.3	2 01; 12 04; 22 08
Y Aurigæ	21.5	+42 21	9. —	3 20.6	1 00; 8 17; 16 10; 24 04
SV Tauri*	45.8	+28 05	9.4—11.0	2 04.0	4 10; 10 22; 17 10; 23 22
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	2 10; 7 23; 13 11; 24 13
RS Orionis	6 16.5	+14 43	7·8— 8.5	7 13.4	4 13; 12 03; 19 16; 27 06
T Monoc.	19.8	+ 7 08	6. — 8.	27 00.3	6 01
57.1908 Gem.	23.7	+67 06	11.0—12.8	0 11.5	1 03; 10 17; 20 08; 29 22
W Gemin.	29.2	+15 24	6.8— 7.6	7 22.0	7 20; 15 18; 23 16
ζ Gemin.	6 58.2	+20 43	3.7— 4.5	10 03.7	10 23; 21 03
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5	13 03
RR Gemin.	7 15.2	+31 04	9.7—10.6	0 09.5	4 09; 12 08; 20 07; 28 05
V Carinæ	8 26.7	−59 47	7.2— 8.0	6 16.7	5 20; 12 12; 19 06; 25 22
T Velorum	8 34.4	−47 01	7.5— 8.5	4 15.3	1 16; 6 07; 15 14; 24 20
W Carinæ	9 19.2	−55 32	7.5— 8.5	4 08.9	3 06; 12 00; 20 18; 29 11
S Antliæ*	27.9	−28 11	6.7— 7.8	0 07.8	2 18; 9 05; 15 17; 28 16
W Ursæ Maj.	9 36.7	+56 24	8.	0 04.0	5 22; 12 14; 19 06; 25 22
RR Leonis	10 02.1	+24 03	9.1—10.0	0 10.9	6 00; 12 19; 19 14; 26 09
ST Ursæ Maj.*	11 22.4	+45 44	6.7— 7.2	8 19.2	1 14; 10 10; 19 05; 28 00
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	3 06; 9 21; 16 11; 23 02
S Muscae	12 07.4	—69 36	6.5— 7.3	9 15.8	9 10; 19 02; 28 18
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	6 00; 11 17; 17 10; 23 03
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	4 22; 11 15; 18 09; 25 03
R Crucis	18.1	−61 04	6.8— 8.0	5 19.8	3 19; 9 15; 15 11; 27 02
S Crucis	48.4	−57 53	6.6— 7.8	4 16.6	2 10; 7 03; 16 11; 25 21
RZ Centauri	12 55.6	−64 05	8.5— 8.9	0 22.5	3 01; 10 13; 18 01; 25 13
W Virginis	13 20.9	− 2 52	9.0—10.0	17 06.5	10 23; 28 06
RV Ursæ Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	1 03; 8 03; 15 04; 22 04
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	7 07; 15 12; 23 17
V Centauri	25.4	−56 27	6.7— 7.6	5 11.9	4 04; 9 16; 15 03; 26 03
RS Bootis	29.3	+32 11	8.9—10.	0 09.1	2 22; 10 11; 18 00; 25 13
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	4 04; 11 14; 19 00; 26 10
R Triang. Austr	15 10.8	−66 08	6.7— 7.7	3 09.3	1 14; 8 09; 15 04; 28 17
S Triang. Austr	15 52.2	−63 29	6.5— 7.5	6 07.8	3 22; 10 06; 16 14; 22 22
S Normæ	16 10.6	−57 39	6.5— 7.4	9 18.1	4 14; 14 08; 24 02
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	2 22; 11 19; 20 16; 29 12
RV Scorpii	16 51.8	−33 27	6.8— 7.6	6 01.5	6 08; 12 09; 18 11; 24 12
u Herculis*	17 13.6	+33 12	5.1— 5.6	2 01.2	5 14; 11 18; 17 22; 24 01

Maxima of Variable Stars of Short Period not of the Algol Type.
Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in February 1912.					
	h m	° ′		d h	d h	d h	d h	d h	d h	
RV Ophiuchi*	17 29.8	+ 7 19	9.—< 11	3 16.5	3 12;	10 21;	18 06;	25 15		
X Sagittarii	41.3	−27 48	4.0— 6.0	7 00.3	4 09;	11 09;	18 10;	25 10		
Y Ophiuchi	47.3	− 6 07	6.2— 7.0	17 02.9		13 01				
W Sagittarii	17 58.6	−29 35	4.8— 5.8	7 14.3	3 01;	10 16;	18 06;	25 20		
Y Sagittarii	18 15.5	−18 54	5.8— 6.6	5 18.6	2 15;	8 10;	14 04;	19 23		
U Sagittarii	26.0	−19 12	7.0— 8.3	6 17.9	7 14;	14 08;	21 02;	27 20		
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	9 01;	19 10;	29 18			
Y Lyrae	34.2	+43 52	10.5—12.	0 12.1	6 23;	13 00;	19 01;	25 01		
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	4 00;	9 03;	14 05;	24 11		
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	1 02;	6 01;	15 23;	25 21		
β Lyrae *	46.4	+33 15	3.4— 4.5	12 21.8	4 01;	16 23;	29 20			
κ Pavonis	18 46.9	−67 22	4.0— 5.5	9 02.2	5 20;	14 32;	24 00			
U Aquilae	19 24.0	− 7 15	6.4— 7.1	7 00.6	1 19;	8 20;	15 20;	22 21		
XZ Cygni	30.4	+56 10	8.7— 9.3	0 11.2	3 00;	7 15;	17 00;	26 07		
U Vulpec.	32.2	+20 07	6.9— 7.6	7 23.5	2 04;	10 04;	18 03;	26 03		
SU Cygni	40.8	+29 01	6.6— 7.4	3 20.3	7 13;	15 06;	22 22			
η Aquilae	47.4	+ 0 45	3.5— 4.7	7 04.2	1 11;	8 15;	15 19;	23 00		
S Sagittae	51.5	+16 22	5.6— 6.4	8 09 2	4 07;	12 16;	21 01;	29 10		
X Vulpec.	19 53.3	+26 17	8.5— 9.1	6 07.7	2 15;	8 22;	15 06;	27 21		
XX Cygni	20 01.3	+58 40	10.5—11.5	0 03.2	5 11;	12 05;	18 23;	25 17		
V Vulpec. *	32.3	+26 15	8.0— 9.0	37 19 0	1 14					
X Cygni	39.5	+35 14	6.4— 7.7	16 09 3		15 17;				
T Vulpec.	47.2	+27 52	5.5— 6.5	4 10 5	1 18;	10 14;	19 11;	28 08		
WZ Cygni *	49.3	+38 27	9.8—10.8	0 14.0	3 22;	9 18;	15 15;	21 11		
WY Cygni	52.3	+30 03	9.5—10.3	0 13.5	6 14;	12 04;	17 19;	23 10		
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	4 15;	13 14;	22 13;	27 01		
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4		10 06;	25 00			
VY Cygni	21 00.4	+39 34	8.9— 9.5	7 20.6	3 01;	10 22;	18 19;	26 15		
VZ Cygni	21 47.7	+42 40	8.4— 9.2	4 20.7	2 08;	7 04;	16 22;	26 15		
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.6	8 02;	16 18;	25 09;	29 17		
δ Cephei	25.5	+57 54	3.7— 4.9	5 08.8	1 20;	7 04;	17 22;	28 16		
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1		10 18;	21 15			
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	2 00;	8 10;	21 06;	27 16		
V Lacertae	44.5	+55 48	8.2— 8.9	4 23.6	4 03;	9 03;	14 02;	24 02		
X Lacertae *	22 45.0	+55 54	8.2— 8.6	5 10.6	4 08;	9 19;	15 05;	20 16		
SW Cassiop.	23 03.7	+58 12	9.2— 9.7	5 10.6	6 04;	11 15;	17 01;	27 22		
RS Cassiop.	32.6	+61 52	9.1—10.0	6 07.1	2 16;	8 23;	15 06;	27 20		
RY Cassiop.	47.2	+58 11	9.2—10.0	12 03.4		10 02;	22 05			
U Pegasi	23 52.9	+15 24	9.0— 9.7	0 04.5	1 05;	8 17;	16 05;	23 17		

COMMUNICATIONS QUESTIONS AND ANSWERS.

[This department is designed especially for the use of amateurs. Beginners are invited to send in their puzzling questions. The editors will try to see that answers are given to reasonable questions but will not hold themselves responsible for the correctness of the views expressed in the communications which may find place here. All communications should be brief.]

Occultation of Venus, November 16, 1911.—Today in brightest sunlight I observed an occultation of the planet Venus by the moon. I noticed the approaching conjunction from a car window as I was coming to this place from Frisco, and when I first saw them Venus was about two diameters of the moon east of the extreme southern end of the crescent. As I watched them I could see them creep sensibly closer and closer and I was quite sure that there would be a very close conjunction if not an occultation, and began to wonder if I would reach my destination here in time to get out my large spy

glass (which I always carry in my suit case,) and observe the phenomenon through that. As I stepped from the train, at 12:20 Pacific Standard Time, the planet looked like a huge diamond suspended from the very *tip* of the southern limb of the crescent moon. I hastened to the hotel, got out my spy glass and ran to a corner near, where I used an old shed as a means of support in steadying the glass. As I looked I saw Venus—a tiny half moon—hugging close up to the dark edge of the moon just south of the tip of the crescent. As I looked, a party of school girls came by to whom I explained the impending phenomenon and they with no optical aid whatever, and I through the glass saw the planet begin to fade in brightness and finally disappear entirely behind the dark portion of the moon *below* the crescent. Being so near the southern edge I knew the occultation would be of only a few minutes duration. As I looked I saw the tiny half moon of the planet seemingly thrust the northern limb into the darkness—and so continue little by little—the darkness creeping southward until the whole of the planet was lost to view. The first I noticed that the occultation had begun was about 12:31. I kept my eye at the eyepiece and the planet disappeared entirely about 12:34. It began to reappear at 12:45 or *near* that and in about three minutes the planet was again in full view really outshining the moon for brilliance in the glass. The girls were unable to see the planet until it was about *half* out and we were all very much delighted to have seen such a very unusual sight as a naked eye occultation by daylight, practically at noon, with the California sun shining its brightest. It was a very beautiful sight and I suppose all the observatories in this country saw it where the weather was favorable. I was the more pleased because it was all an accident that I saw it at all, having had no warning nor having seen any journal of any kind that foretold it. It must have been a beautiful sight through a large telescope and I hope to read of such observations in your very excellent POPULAR ASTRONOMY.

ALVIN M. WHITNEY.

Ukiah, Cal. Nov. 16, 1911.

Occultation of Venus.—Comet Borelly.—Thursday November 16, 1911 will long stand in my records as of unique interest. In a clear blue sky Venus and the moon stood in conjunction and at the noon hour it was plain that the planet was almost certain to be occulted. At 12:30 P. S. T. I stood with field-glass in hand, the two celestial bodies being now in apparent optical contact. At 12:34 Venus disappeared with great suddenness back of the dark body of the moon which was visibly west of the illuminated crescent, making a striking spectacle. Twelve minutes later the planet emerged as bright as ever. It set behind our western mountains at 2:14.

Occultations of the major planets occur but rarely, and still more rarely in full daylight.

Having plotted upon a star atlas the ephemeris position of Borelly's comet (1905 II) for the 19th instant and deduced the presumable position for this evening as at a spot in Eridanus south of the stars τ^4 and τ^5, and forming a fairly equilateral triangle with these, I directed the telescope at 9:30 to this area. At the inferred location was an object exceedingly dim in the finder but which the telescope promptly showed to be the desired comet. The nucleus exhibited a faint glow and the comet was estimated as of about the eighth magnitude.

How rich this season is in comets!

EDWARD GRAY, M. D.

Eldridge, California.

Independent Discovery of Beljawsky's Comet.—Comet *g* 1911 was observed, separately, by two employees of the Sonoma State Home, Eldridge, California, on October 1, and again on October 3; by the dairyman about 4 A. M. on October 1, and again on October 3 (the intervening morning, October 2, was cloudy); and by our night watchman, Stephen Malone, on the morning of October 3, (perhaps also on the first). He did not report the matter to me however for some four or five days; nor call me up at the time. When asked why he did not call me up at that morning he replied that he thought that it was "the same comet"—meaning Brooks' *c*—which had come to the east. Neither of these two communicated with the other and neither appreciated the interest taken in them by astronomers.

EDWARD GRAY.

The Cincinnati Astronomical Society.—Miss Mary Proctor lectured Friday evening November 10, at the Ohio Mechanics Institute, under the auspices of the Cincinnati Astronomical Society. Her subject "Other Worlds than Ours" was illustrated with nearly a hundred choice slides. She was listened to very attentively by an audience of over five hundred people.

Announcement was there made of the incorporation of the Astronomical Society. Papers filed with the Secretary of State at Columbus, set forth the purposes of the society as follows: For promoting the study of astronomy and the allied sciences: for the advancement of knowledge in related lines of research; for the establishing and maintaining of astronomical and astrophysical instruments, equipments, real estate and buildings in the city of Cincinnati or its vicinity; and for the purpose of securing and administering trust funds for the permanent endowment of the astronomical and astrophysical researches of this society and its members."

There are about seventy-five members of the society. Quite a number of them have telescopes of their own.

DE LISLE STEWART.

The Conjunction of Mars and the Moon November 4, 1911.—For persons who love the observation of the celestial phenomena the conjunction of Mars and the moon, which occurred on the evening of Monday November 4 last, was a beautiful sight.

The moon was in its fourteenth day, and Mars was so near our satellite that in some moments it was very difficult to distinguish the reddish and mysterious planet, among the yellowish radiations of the Queen of Night.

At eight o'clock, local time, the right ascension of the moon's center was $3^h\ 41^m$ and the right ascension of Mars' center was $3^h\ 43^m$, so the difference was only two minutes or 30 minutes of arc, and as the moon's radius is about 16′, the distance of Mars to the moon's obscure limb was 14′, less than the Moons radius.

Mars passed afterwards to the south of the moon, just in front of Tycho and a little after nine o'clock our pale satellite was exactly between the Pleiades and the mysterious Mars.

It was, indeed, a pretty celestial sight.

PROF. LUIS G. LEÓN.

Mexico, December 6, 1911.

Motion in a Resisting Medium.—Reading the article on Gravity and The Earth's Motion by Hyland C. Kirk in the November number of P. A. again brought to my mind a question which has bothered me for ever so long and to which I have not as yet seen any reference in the few astronomical books which I have read. Namely the curve of the pitched baseball. Since the forward orbital motion and the rotary axial motion of planets is similar to the motions of a ball pitched for a curve, and if there is any resistance in the substance of space within the solar system, should not this produce a force tending to drive the planet toward the sun if it travels close to the plane of the ecliptic and the inclination of its axis is small; otherwise, if inclination of orbit and obliquity of axis is great, tending to force it toward the ecliptic again? If one of the planetary satellites having a retrograde orbital motion should also have a reversed axial motion, would it not tend to drive the satellite away from its primary. Hoping that, if these questions are not too childish to be worth considering, I may see an answer in an early issue of P. A.

NELS BRUSETH.

Silvana, Wash. Dec. 2, 1911.

Occultation of Mars by the Moon.—Thinking that the incidents recorded below may be of interest and value to some others, I give my recent experience on the 4th of December in viewing the occultation of Mars by the moon.

From the data given in the *Nautical Almanac* I had formed the opinion that there would be no occultation whatever. It happened that on the evening of the 4th of this month I was taking a trip through the northeastern part of South Dakota and along towards eight o'clock in the evening it became evident that Mars was going behind the moon. I record here a few notes taken from my note book as I jotted them down that evening:

At 8:05 P. M. (C.S.T.) as I left the car at Doland, S. D., I concluded that Mars was about 5′ or 6′ to the south and east of the moon.

At Raymond, S. D., at 8:25 P. M. Mars was 3′ from the Moon.

My next observation was made on board the train at 8:45 and at this time Mars was entirely invisible.

I should estimate that probably Mars went behind the moon at 8:37 to 8:40 P. M. I made a number of observations at the various stations that we passed through, and at Henry S. D., at 9:34P. M., Mars was still invisible. At 9:50P.M. at Kampeska, S. D., Mars was 2′ or 3′ from the edge of the moon on the opposite side and from the observation made should judge that it came out from behind the moon at about 9:40 to 9:45. It was thus evident that Mars was behind the moon very close to an hour, possibly an hour and a few minutes.

I had not thought so much of my notes until the next day when I met Professor Leavenworth of the University of Minnesota in Minneapolis and he

told me that he had observed the conjunction of Mars and the moon and that there was no occultation whatever, Mars being not nearer than 2′ or 3′. The comments on the above data may be of value. While these small places are possibly unfamiliar to many people, they are all on the Northwestern Railway and on that branch leading from Gettysburg, S. D. to Mankato, Minn. These small places mentioned are between Redfield and Watertown, S. D. By rail Watertown is about two hundred and sixty miles from Minneapolis. It is quite probable that it would not be farther than two hundred and twenty-five or two hundred and thirty miles in a straight line. Redfield and Watertown are about seventy miles apart. At first reflection a person would hardly think that there could be so much difference in the details connected with an occultation of Mars by the moon as viewed from two stations relatively so close at hand. Professor Leavenworth is sufficient authority for the observation of the occultation at Minneapolis and he has a photograph taken that evening to substantiate his observation. I can only add with regard to my own observation that these observations at the different places were definitely noted in my pocket memorandum and both the place and the exact time was written down each time. My watch was within two or three seconds of being absolutely correct. All these readings are in Central Standard Time. The only possible element of uncertainty is as to the exact number of minutes Mars was occulted but it could not have been many minutes less than an hour. The sky was clear and there was not the least difficulty in tracing Mars even to its closest position to the moon.

I shall be glad to hear of any reports of others who viewed this occultation or conjunction at other places.

Ruel W. Roberts.
Director Fort Pierre Observatory.

Gravity and the Earth's Motions.—There are several obvious difficulties in connection with Mr. Hyland Kirk's theory of gravitation, which he has not mentioned in his article "Gravity and the Earth's Motions", vide Popular Astronomy, November 1911. Any theory, however improbable it at first appears, should deserve the fullest consideration from either standpoint, but in this instance, the apparent disadvantages attached to its acceptance do not seem to have been pointed out as clearly as the arguments in its favor.

I gather from this article that the author considers matter in itself has no attraction, but that this is supplied in the case of the earth by the resultant of the external forces which impel our planet upon its spiral path. Now even if we were to grant that this is the cause of the earth's cohesion as a whole, it would scarcely explain the phenomena of intermolecular attraction, or of magnetism, which appear to demonstrate indisputably the presence of attractive and repulsive forces in matter under certain conditions. Nor does it simplify our comprehension of the forces at work in the universe, if we are obliged to consider that the cause of a body falling towards the earth is different to that which accelerates our planets motion when approaching perihelion. For I presume Mr. Kirk does not believe that the force which keeps the earth in its orbit is the resultant of a couple set up by our motion towards Vega, combined with still another motion, say a drift of the Galaxy in some other direction.

Moreover there is the improbability of the two forces he mentions providing exactly the ratio required to give the earth its present shape. Although we might assume from absence of any evidence to the contrary, that the velocity of the solar system as a whole is constant, this is certainly not the case in regard to the terrestrial motions, and the variation of the latter's aphelion and perihelion velocities would present a considerable drawback to this theory.

Then, again, the different orbital speeds of each planet offer a similar difficulty, as it could hardly be maintained that their respective masses and times of rotation would compensate for their unequal orbital velocities.

A far greater objection, however, to this theory of terrestrial rotation and cohesion, lies in the fact that it is based on the assumption that the solar system is moving in an orbit over which we are supposed to take an average of more than 60 years to move over one second of arc. For centrifugal force can only be set up by an impulse which impels the particles of matter in any particular body to travel with different velocities or directions, and as the solar system would be moving to all intents and purposes in a straight line, such an impulse would be practically non-existent. It would, therefore, seem that the strain to which the earth is subject in its journey with the solar system is too small to play such an important part in terrestrial affairs; calculations from the data mentioned in the article in question showing, indeed, that this centrifugal force is but little more than $\frac{1}{10^5}$ of that produced by our annual journey round the sun. The inadequacy of the former influence is rendered the more evident, when one considers that the plane of our planets rotation coincides more nearly with that of the ecliptic, than with the apex of the sun's way, so that, in order to provide the necessary cohesion of our sphere, the force derivable from our annual motion should be actually *less* than that due to the movement of the whole system!

One other point I feel is open to query, and that is the observation that 'The same influences being exerted on the moon, the latter must act in accord with the reactions set up by its more powerful companion, thus causing our luminary to rotate but once in its circuit about the Earth'. But surely the centrifugal force of the lunar revolution should not be forgotten in any endeavor to make theory accord with facts. Roughly speaking this force is equivalent to nearly half of that derived from the earth's annual motion, and as the former acts almost in the plane of the ecliptic the moon ought to have a more rapid rotation than the earth, unless of course we suppose lunar tides to have been raised in the same manner as is ascribed in the article to our own, and the moon's rotation to have been reduced by the ensuing tidal friction.

The principal, indeed, the only argument unfavorable to the supposition of attractive force in matter, would seem to be that a slight increase is noticeable in the intensity of gravitation at a short distance below the earth's surface. The evidence however, obtained at points varying only about $\frac{1}{10{,}000}$ part of their total distance from the center of gravity can hardly be accepted as conclusive, and this slight additional intensity might be caused by some other factors, amongst them the decrease in the centrifugal force of the earth's rotation and the increase in the density of matter.

No doubt most of the objections enumerated in this letter have occurred to the author, but they should I think, be dealt with, before this theory can be considered at all possible.

B. G. HARRISON.

Royal Societies club, London.
November, 1911

The Conjunction of Venus and Jupiter January 9, 1912. A correspondent from Norwood, Mass. thus calls attention again to the conjunction of Venus and Jupiter on January 9, which was mentioned in our "Planet Notes" last month:

Two gems upon the lucent brow of day,
The Sire of Gods and Queen of Love are seen;
With steady light they deck the clear serene
Among the twinkling stars, less bright than they.
Eastward Antares shoots his fiery ray,
Arcturus ruddy, Libra's star of green,
White Spica far above, with paly sheen—
All sparkle, as with various tints they play.

A lovely view, though not without its awe.
The silent planets shed commingled light,
Outshining all the starry hosts above;
A heavenly scene, yet type of earthly law,
That all things mundane yield before the might,
The union sweet, of Fatherhood and Love.

The Audibility of the Aurora has been mentioned in POPULAR ASTRONOMY, I would be glad to qualify and testify as witness if such testimony is admissable.

Few Indians, I believe, who live out of doors in the old northwest or in the prairies of western Canada would question the occasional audibility of the aurora. Scientists and explorers do. First they ascribe sounds described by the Indians to ice in cold weather. Second they think the aurora to be too high above the earth to be audible.

First. It seems to me that although the sounds have similarities more difficult to describe than to differentiate in experience, it would be easy to prove that the vibrations of one ought to be much more rapid than the other and therefore of a different pitch.

Second. Accredited scientists have seen aurora so low as to appear between the observer and a house at a little distance.

When living in houses or surroundings common to congested communities or where mind and ears, in any locality, are occupied with immediate employment or surroundings I have never heard the gentle sound of the aurora but have heard lower pitched sounds of miles of ice on Lake Shetack, Minnesota, sing under temperatures of 34 degrees below zero and lower. In 1888 studying surveying at Carleton College, we did field work with the theodolite. One day the needle would touch the glass when our fingers touched the glass. The variations of the needle were not constant, etc. We reported to you, and after explaining the cause, an electric storm, and that probably the electric storm

was due to a sunspot appearing in the sun, we were shown the sunspot on the limb of the sun through the telescope in Goodsell Observatory. The memory of your kindness to us that day has always been a pleasure.

In the years since at one time for a tonic I took static electricity, seated in an isolated chair under an inverted cone or helmet, from the latter of which electricity descended when the generator was started.

In late August 1904 on an isolated hill in S.W. Minnesota, far from people and moving things, in absolute quiet perfectly alone with nature, on a still and lovely but cool evening, when enjoying the great out of doors, the gentle rustling, crackling, snapping sound as if a shower of static or other electricity had descended behind me, caught my ear. I turned quickly and looked N. E. and behind me low, with compressed subarc cloud and depressed arc, there glowed not brightly an aurora. It might have rebounded from the earth. When I had walked 400 feet, the aurora was high, arc usual height and streamers becoming more bright, shooting higher and higher toward the apparent focus. There was no sound except in the possible descent. Then however the aurora attracted my attention to itself by its audibility.

WM. J. PELL.

Oak Park, Ill. Oct. 10, 1911.

Question:—Meaning of Symbols T, ω, Ω etc. Please give in POPULAR ASTRONOMY a brief explanation of the symbols used in giving the data of comets.

ANSWER:—We presume that the writer understands that a comet, as well as each of the planets, moves in a plane which passes through the center of the sun, and that a comet's orbit is a very much elongated ellipse, if not a parabola. The point of the curve which is nearest to the sun is called the perihelion point. Bearing these facts in mind the following definitions of the symbols will be readily understood.

T = the time of perihelion passage, usually expressed in Greenwich mean time.

Ω = the longitude of the line of intersection of the plane of the comet's path with the plane of the ecliptic or earth's path. Or it may be defined as the longitude of the point where the comet passes through the plane of the ecliptic from south to north. Thus it is called the longitude of the ascending node.

i = the angle of inclination of the plane of the comet's path to the plane of the ecliptic.

q = the distance of the perihelion point from the sun, expressed in units of the earth's mean distance from the sun. Generally the logarithm of this quantity is given.

a = the semi-major axis or one half the total length of the orbit.

e = $\sin \phi$ = the eccentricity of the orbit or the ratio of the sun's distance from the center to the semi-major axis.

μ = the average daily angular motion of the comet, usually expressed in seconds of arc.

r = the distance of the comet from the sun at any moment, in units of the earth's mean distance.

Δ or ρ = the distance of the comet from the earth, expressed in the same units as above. The logarithms of these quantities are usually given.

Br= brightness or light. This is the ratio of the brightness of the comet on any date to that on some particular date, usually the date of discovery. It is calculated on the theory that the light is all reflected sunlight, and takes no account of chemical or physical changes which render the substance of the comet self-luminous, as seems to be the case in many instances.

Question:—Littrow's Formula:—A correspondent asks answers to the following questions:

1. Where can I find Littrow's Formulæ for making achromatic eyepieces for telescopes and microscopes?

2. How to trisect and quinquesect an angle less than a right angle or an angle of 180°; by the direction given on *Graduation* in the Encyclopedia Britannica, in the parts on hand graduation? Was it done by simply stepping with the dividers; or is there a geometrical method to be followed, similar to the bisection of an angle?

COMET AND ASTEROID NOTES.

New Comet *h* 1911 Schaumasse.—A cablegram from Kiel, Germany, received at Harvard College Observatory December 2 announces the discovery of a new comet by Schaumasse at Nice, France, on the night of November 30. The position given is in the constellation Virgo about seventeen degrees almost directly north of Spica. Daily motion east $3^m\ 32^s$ and south 13′. The comet is described as visible in a small telescope. The following positions are all that have come to hand:

Greenwich M: T.	α h	m	s	δ °	′	″	Observer	Place
1911 Nov. 30.6991	13	12	12	+5	51		Schaumasse	Nice
Dec. 2.6958	13	19	17.6	+5	24	29	Abetti	Arcetri
4.7482	13	26	25.7	+4	57	05	Biesbroeck	Uccle

A cablegram received at Harvard College Observatory December 8 gives the following elements and ephemeris computed by Fayet and Schaumasse from observations made on November 30, December 1 and 2:

ELEMENTS.

Time of perihelion passage	$= T =$	1912 Feb. 5.35 Gr. M. T.
Perihelion minus node	$= \omega =$	109° 08′
Longitude of ascending node	$= \Omega =$	115 12
Inclination	$= i =$	20 29
Perihelion distance	$= q =$	1.170

EPHEMERIS.

Gr. M. T.	R. A. h	m	s	Decl. °	′	Light
1911 Dec. 8.5	13	40	30	+4	04	1.40
12.5	13	55	39	+3	06	
16.5	14	11	15	+2	08	
Dec. 20.5	14	27	17	+1	09	1.90

Ephemeris of Schaumasse's Comet *h* 1911.

Greenwich Midnight 1912	α h	α m	α s	δ °	δ ′	δ ″	log *r*	log Δ
Jan. 4	15	30	30	−2	32	4	0.10499	0.19594
12	16	5	39	4	23	20	0.08971	0.18665
20	16	41	3	6	4	51	0.07801	0.18187
28	17	16	8	7	33	25	0.07063	0.18124
Feb. 5	17	50	18	8	47	35	0.06819	0.18416
13	18	23	9	−9	45	19	0.07083	0.18974

The above ephemeris is based upon Fayet's elements in the last number of of Harvard College Observatory bulletin. The ephemeris is right if those elements are right. Comet nearest earth last week in January 1912.

F. E. SEAGRAVE.

Providence, Dec. 12, 1911.

Comet *d* 1911 Borrelly:—This comet on December 18 was quite conspicuous in the 5-inch finder at Goodsell Observatory, being 3′ or 4′ in diameter with a faint trace of tail extending toward the N.E. The nucleus with the 16-inch telescope was quite star-like and of about the eleventh magnitude.

Elements of Encke's Comet:—In *A. N.* 4539 Professor O. Backlund gives the following elements of Encke's comet which satisfy the observations in 1911 quite satisfactorily:—

Epoch and osculation 1911 June 11.0, Berlin M. T.

$M_0 = 339° 21′ 48″.12$
$\phi_0 = 57 54 58 .11$
$\Omega = 334 29 32 .03$
$\pi = 159 09 01 .26$ } 1911.0
$i = 12 34 31 .91$
$\mu_0 = 1075″.66813$
$M = M_0 + \mu_0 t + 7″.54\,\tau^2$
$\mu = \mu_0 + 0″.01258\,\tau$
$\phi = \phi_0 - 0″.42\,\tau$

An Interesting Asteroid.—A letter has been received from the Rev. Joel H. Metcalf, stating that he has photographed an asteroid, which seems to be new in the following positions for 1910.0:—

Oct. 24 1911	G. M. T.	$14^h 49^m 30^s$	R. A. $2^h 54^m 25^s$	Dec. +26° 29′.4
Nov. 13 1911	"	11 58 30	2 36 56 2	+22 26 .7

Two things about this asteroid are interesting, its brightness, about 10.5 magn., and its rapid change in declination, — 12′ per day for 20 days.

Several photographs of this object were obtained at the Harvard Observatory on November 15 with the 16-inch Metcalf telescope. They confirm its brightness, as it is a conspicuous object with 10m exposure.

EDWARD C. PICKERING.

Astronomical Bulletin No. 478.
Harvard College Observatory,
November 16, 1911.

NOTES FOR OBSERVERS.

The Society for Practical Astronomy.—Mr. Frederick C. Leonard writes that the society for Practical Astronomy has the following working sections in addition to the "Planetary and Lunar Section" which we mentioned last month:

Section	Director	Address
Solar	Richard H. Swift	4839 St. Lawrence Ave., Chicago.
Photographic	Horace C. Levinson	4049 Lake Ave., Chicago.
Meteor	Prof. Chas. P. Oliver	Agnes Scott College, Decatur, Ga.
Comet	Weston Wetherbee	5 Ingersoll St. Albion, N.Y.
Double Star	Hibbert Perceval Newton	Irvine's Landing, B.C. Canada.

The Society now numbers 54 members and if all of these are actively engaged in definite lines of study, we may expect a great deal of valuable work to be done in branches of astronomy which the professional astronomer must largely neglect. There must be many more who possess telescopes of moderate power who would like to join in some definite line of work. If you are not already enrolled in one of these sections, write to the director of the one in which you are most interested and see if he cannot give you something definite to do in which you will be coöperatiug with others.

The Monthly Report of the American Assocation of Variable Star Observers.—It is a pleasure to report that variable star observing is rapidly becoming popular among telescopists in the United States, and this plan of coöperation is meeting with favor. Those who have lately joined the Association are as follows:—

Mr. E. L. Forsyth, Needles, Cal.
Mr. Harold B. Curtis, New York City.
Mr. E. L. Pickering, Ridgetown, Ont.
Mr. John Manning, Trenton, N. J.
Mr. R. H. McAdams; Due West, S. C.
Mr. Paul Shogren, Montclair, N. J.
Rev. Victor Stepka, Clayton, Mo.
Mr. Charles Masterson, Angola, Ind.
Mr. Charles Y. McAteer, Pittsburg, Pa.
Mr. Ralph D. Rust, Mansfield, Ohio.
Mr. John K. Dow, Spokane, Wash.

Our Association now has a membership of twenty-five observers,—thirteen states and Canada being represented.

As many of the new members of the Association are observing the variable 193449 R. Cygni, the following notes concerning it may be of interest:—

This variable was discovered by Pogson in 1852. Its range is from 5.9—8. to a magnitude below the 14th, with a mean period of 425.7 days. According to Gore, bright lines were seen in its spectrum in 1888. The existence of these was confirmed by Maunder at Greenwich. One of these lines was found to coincide with the F line of hydrogen. Bright hydrogen tints are characteristic of the long period variable stars. Peek has seen a bluish nebulosity involving this star at its minimum.

A maximum of 6.6 was observed at Harvard on June 11 1901, and another of 8.0 magnitude by Grover on September 3, 1902.

C. L. Brook, the Director of the V. S. S. of the B. A. A., regards this a difficult star to observe, both on account of its color, its proximity to θ Cygni and its faintness at minimum.

According to a list of maxima and minima of long period variables published by the V. S. S. of the B. A. A. there was a minimum of this star July 22nd 1911, and a maximum will occur Dec. 26 1911. R Cygni is in the class of the so-called "Rapid Increase Variables." At present, (December 11) it is easily visible in a binocular, and an interesting variable to observe.

VARIABLE STAR OBSERVATIONS Nov.. 10 to Dec. 10, 1911.

TABLE I.

	Observers	Olcott 3″										Hunter 5″				Jacobs 3″			
	Dates	11	13	15	22	25	26	27	4	6	7	8	10	11	13	19	10	13	21	30
1	T Androm.		11.0		9.7			9.4			9.2									
2	ST Androm.		9.2		9.1									8.8	8.8					
3	V Androm.		10.7		11.0								9.8							
4	RW Androm.									10.5									11.0	10.5
5	R Aquarii		10.0																	
6	T Aquarii		8.6		8.7												8.7	8.7	8.8	9.0
7	W Aurigae		9 7		10.5															
8	R Camelop.	8.8		9.0	8.8	8.7			8.6										8.4	8.1
9	V Camelop.		9.6		9.5							10.5								
10	X Comelop.		10.3		9.3						8.5									
11	T Cephei	8.0		8.1	8.1		8.4			8.6								8.3	8.4	8.6
12	o Ceti		8.2		8.6	8.6					8.8					9.0				
13	R Cygni	6.7		6.6	6.4			6.2	6.4			6.6								
14	U Cygni	9.4									9.4						9.4		9.6	9.6
15	X Cygni	8.0		8.7	9.0	9.0			9 6			9 8					7.9		8.8	9.4
16	RS Cygni								7.2			7.6					8.3		8.3	8.0
17	S Lyncis		9.0		9.0							10.2								
18	U Lyncis		9.9		9.8							9.9								
19	W Lyrae	7.9		8.4	8.3			8.5		8.7										
20	R Pegasi	9.0		9.0	9.6	9.3				9.5										
21	W Persei	9.4		9.4		9.6					9.4		9.0							
22	W Tauri		9.2		9.8	9.5					10.0									
23	R Vulpec.	8.9		9.0	9.3	9.4					10.2						8.9	9.3	9.5	9.9

TABLE I. Continued.

	Vrooman 5″						Miss Young 8″							Miss Swartz 3″				Dr. Gray 3½″							
	13	15	18	21	25	26	16.	18	22	25	1	2	7	13	16	21	22	10	14	17	21	23	24	25	26	27
1							10.1				9.1															
2														8.7			9.6									
3																										
4																										
5																										
6	8.3			8.4																						
7																										
8																										
9																								10.3		
10							10 4					8.7														
11		8.1			8;2																					
12			8.1			9.0												8.6	8.6	8.7	8.7					8.8
13			6.6												6.4			6 8		6.6					7.0
14																9.5										
15																				8.1		8.4				8.7
16																							9.3			
17																										
18																										
19										8.5		8.6														
20									9.2																	
21																										
22									9.1			10.1														
23																										

TABLE II.

		Vrooman			Hunter					Jacobs				Miss Young		
		15	18	25	11	13	21	25	26	10	13	20	30	16	18	2
1	R Androm.	9.6		8.6	9.2	9.1			8.4							
2	R Cassiop.			11.2												
3	RT Cygni															
4	SS Cygni						11.6	11	6	11.5	11.9	11	9 12.0	11.5	11.7	11.7
5	T Draconis		10.8													
6	R Scuti															
7	T Herculis		10.8													
8	Y Persei								11.0							

TABLE II. Continued.

	Miss Swartz		Dr. Gray								
	21	22	10	14	16	17	20	21	22	72	28
1											
2											
3	8.9							9.1	9.3	9.5	
4											
5				5.4	5.3	5.5	5.5		5.6		5.0
6											
7		9.6									
8											

TABLE III.

	Jacobs							Miss Young										
	10	13	15	17	21	29	30	13	16	18	22	25	27	1	2	4	7	21
RU Androm.					10.7		10.3											
U Arietis											12.6				12.0			
R Aurigae					10.9		11.0				9.5						10.5	
S Aurigae												8.6					9.0	
Z Aurigae											8.7						9.5	
S Bootis					10.1													
S Camelop.											8.6						8.7	
T Camelop.										12.5					11.3			
S Cassiop.					8.9		8 9											
T Cassiop.					11.1		11.5							11.5				
U Cassiop.									13.2					11.4				
V Cassiop.	11.0				10.1		9.9											
W Cassiop.	9.5				9.4		9.1											
X Cassiop.									10.1								10.7	
S Cephei	1.00				10.1		10 1											
R Cor. Bor.			8.4		8.5			8.2			8.3							
X Cor Bor.			9.2		9.1													
RZ Cygni										12.8								
R Draconis		11.4										12.0					12.0	
Y Draconis										12.2								
S Delphini										10 5			11.3					
T Delphini										12.7			12.5					
U Gemin.				12.8		12.7												
S Herculis	11.0		10.7		10.7													
U Herculis								10.1					9.3					
W Herculis													10.8					
R Lacertae											9.6					9.8		
S Lacertae											9 8					10.4		
R Lyncis		9.9			9.9		9.5			9.5							9.1	
R Orionis															11.7			
RT Pegasi											11.7							
R Persei											10.8				12,4			
R Piscium																	12.2	
SU Tauri															9.4			
R Triang.									6.4						6.9			
R Urs. Maj.					7.4	7.3							7.3				7.5	7.8
S Urs. Maj.							8.7			8-0			8.1				8.6	8.8
U Urs. Min.																		

Miss Swartz

In this and future reports observations by different observers that are identical on a certain date will be underscored. In this report we have but one such coincidence.

The fact that some one of our observers was at work on every night, with the exception of six, during the month, speaks well for the coöperative value of this plan.

WILLIAM TYLER OLCOTT.
Corresponding Sec'y.

Norwich, Ct. Dec. 10, 1911.

GENERAL NOTES.

Dr. George Davidson, eminent for his contributions to geodesy, geography and astronomy, emeritus professor in the University of California, has died at the age of eighty-six years (*Science*, Dec. 15, 1911.)

Mr. C. O. Lampland, of the Lowell Observatory, has recently been elected an honorary member of the Sociedad Astronomico de Mexico and Mr. E. C. Slipher of the same observatory, has received its medal for his planetary photographs. (*Science*, Dec. 15, 1911)

Professor Eric Doolittle delivered a lecture before the University of Pennsylvania Chapter of the Sigma Xi, on December 11. His subject was "The recent Discoveries in Stellar Astronomy" (*Science* Dec. 15, 1911.)

Mr. John H. Eadie who has been a subscriber to POPULAR ASTRONOMY for many years, and who contributed occasionally to the Sidereal Messenger, passed away on November 3, 1911, in his seventy-first year, after an illness of three months.

Professor S. A. Mitchell of Columbia University, has been lecturing in Philadelphia on successive Saturdays, beginning with November 4, on the subject of "Astronomy." The titles of the lectures are (1) "Common Things about the Earth," (2) "The Sun—Typical Star," (3) "Evolution Revealed by the spectroscope," (4) "The Moon, a Worn-out World," (5) "Fragments of other worlds," (6) "Is Mars Inhabited?" (*Science*, Dec. 1, 1911.)

Death of Miss Jane M. Smith, Allegheny, Pa.—I am sure many of the readers of POPULAR ASTRONOMY will be concerned to hear that on November 9, Miss Jane M. Smith died very suddenly at her home in Allegheny, in her eightieth year. Her sister, Miss Matilda Smith, had died just two years before. These two women had devoted their lives and resources to philanthropic work, and they were unusually interested in sciences, particularly in Astronomy. Their gifts to the Allegheny Observatory were large and always opportune. Among the institutions remembered in their wills are the Allegheny Observatory, the University of Pittsburgh, the American Association for the Advancement of Science, the National Geographical Society and the American Forestry Association.

FRANK SCHLESINGER.

Allegheny Observatory, Nov. 20, 1911.

Orbit of the Spectroscopic Binary ξ Serpentis.—In the Lick Observatory Bulletin No. 203 Mr. Reynold K. Young gives a determination of the orbit of the spectroscopic binary ξ Serpentis, from 17 spectrograms taken in the years 1902 to 1905, all the others in June and July 1911. The final elements are:

Period = 2.292285 days
T = J.D. 2419209.618 ±.003 days
K = 19.35 ±.04 km.
μ = 157°.049
$a \sin i$ = 610000 km.
Velocity of system = −42.67 ± .13 km.

The orbit appears to be practically circular.

One Hundred New Double Stars.—Dr. Aitken's eighteenth list of new double stars is given in the Lick Observatory Bulletin No. 204. This makes the total number discovered by Dr. Aitken 2400.

Schiaparelli's Measures of Double Stars.—Pubblicazioni del Reale Osservatorio di Brera in Milano N. XLVI contains the second series of observations of double stars by Professor G. V. Schiaparelli, in the years 1886-1900. This series comprises measures of 636 doubles, most of them from the Struve catalogues of Dorpat and Pulkova and those of Burnham and Hough. Most of the stars have been measured on many nights and the results are given for each night. The accuracy and consistency of this long series of measures renders it a very valuable contribution to double star astronomy.

A Practical use of Astronomy.—*The Observatory* October 1911 vouches for the correctness of the facts stated in the following newspaper clipping.

A church spire has recently been saved from destruction in a very odd way. The Astronomer Royal was testing a telescope at the Observatory in Greenwich Park, and chose the spire of St. John's church, Blackheath, a mile away, as a fixed object on which to focus the instrument.

He was astonished to see a serious flaw in the stonework of the spire—there was a gaping fissure through which daylight appeared. The rector was informed, steeplejacks went up, and the crack was found to be about fourteen feet in length. The church is closed and repairs are going on.

The Future Habitability of the Earth.—In reviewing the Smithsonian Report for 1910, a writer in *Science* for December 1, 1911, gives the following account of an article with the above title by Professor Thomas C. Chamberlin: ".....He reviews the past, and considers the future, of the world as a dwelling place for the human race. Many branches of science enter into the discussion, but upon geology, physics, chemistry, astronomy and astrophysics rests the burden of the arguments. Mr. Chamberlin thinks that the earth will remain habitable for tens of millions of years, but concedes that the close approach of a celestial body to the sun would probably result in the disruption of the solar system and bring disaster to the earth. He further states, in regard to the future possibilities of scientific research, that 'when moral purpose and research come to be the preeminent characteristics of our race by voluntary adoption and by the selective action of the survival of the fittest, and when these most potent attributes join in an unflagging endeavor to compass the highest development and the greatest perpetuity of the race, the true era of humanity will really have begun".

The Latest Observations of Halley's Comet.—Professor Percival Lowell, Director of the Lowell Observatory at Flagstaff, Arizona, calls attention to the fact that Halley's comet was photographed at Lowell Observatory on later dates than those mentioned on page 654 of the December number of

Positions of Halley's Comet on Photographs at Lowell Observatory.

POPULAR ASTRONOMY. The accompanying chart shows the position of the comet on photographs taken from May 15 to June 1 by Mr. Lampland with the 40-inch reflector. The exposures varied from 16^m on May 15 to 80^m on June 1. The observations ceased on account of moonlight and after the moon had passed the comet was too near the sun.

Silvering Mirrors.—The paper by Heber D. Curtis on silvering mirrors, which we reprinted in our issues of August 25 and September 1 and 8, contained much valuable information on a subject that is of interest to many, though few people venture on silvering operations themselves. On paper all the methods may appear to be tricky and liable to mishaps, excepting in the hands of experts, but those who care to make practical tests will soon find that the process of silvering is not such a difficult operation as it seems to be. Absolute cleanliness of the glass surface is the chief secret of success, and if the first attempt is a failure, as it often is, a second attempt after renewed cleaning will probably succeed. Perhaps the simplest of the methods described by Mr. Curtis is the one known as Lundin's Method, which we have used with great success. The formula as given does not, however, seem to be quite correct, as it appears to contain far too much formaldehyde. We use only one-tenth the quantity given of this ingredient, and then find the process works excellently. Photographers should find this method of great value for renewing reflex mirrors, and if they follow the silvering with the varnishing process, also described by Mr. Curtis, the result should last a long time. Of course, the old mirror must be thoroughly cleaned before starting operations, and if it was originally varnished, spirit must be used to remove the varnish. A little strong nitric acid will speedily remove the old silver, and then the new silvering process can be begun. The used silvering solution is best thrown away immediately it is done with, as if allowed to stand for a long time a fulminating compound is thrown down which is highly explosive. [British Jour. Phot. October 6, 1911.]

The Distribution of Variable Stars:—In *A. N.* 4538 Mr. Ernst Zimmer gives the results of a study of the distribution of variable stars. He finds them to be very numerous in the Milky Way, and the proportion of stars to be found variable is larger there than elsewhere in the sky, as will appear from the following table:

Galactic latitude	Number of Variables	Relative Number Variables	Stars
+ 90° to + 70°	10	0.14	0.35
+ 70 " + 50	62	0.29	0.37
+ 50 " + 30	101	0.31	0.45
+ 30 " + 10	248	0.63	0.68
+ 10 " − 10	422	1.00	1.00
− 10 " − 30	238	0.60	0.77
− 30 " − 50	93	0.29	0.47
− 50 " − 70	43	0 20	0.41
− 70 " − 90	17	0.23	0.38

For stars of the Algol type and new stars the falling off in number as one goes away from the galactic equator is even more rapid than for variable stars in general. This is shown in the next table.

	Algol Stars		New Stars	
Galactic Latitude	Observed Number	Number Proportional to gen. distrib.	Observed Number	Number Proportional to gen. distrib.
+ 90° to + 70°	0	0	0	0
+ 70 " + 50	2	4	0	1
+ 50 " + 30	10	9	0	2
+ 30 " + 10	17	18	4	5
+ 10 " − 10	41	31	21	9
− 10 " − 30	16	18	1	5
− 30 " − 50	4	7	0	2
− 50 " − 70	0	3	1	1
− 70 " −90	0	1	0	0

Lines in the Arc Spectra of Elements arranged in the order of their wavelengths, from 7950 to 2200, compiled by F. Stanley. Published by Adam Hilger, Limited, 75 A Camden Road, London, N. W., 1911. This volume contains simply a tabular enumeration, without remarks, of the wave-lengths and relative intensities of the lines in the arc spectra of fifty-five elements. Each alternate page is left blank, and the left half of each printed page is also blank so there is abundant room for corrections, insertions and memoranda to be made by the research worker for whom this volume is especially intended. The wavelengths are given in Angstrom units to the nearest unit in the fifth significant figure. The last column gives for each element the next prominent line belonging to that particular element, which will materially assist in determining whether any element is present or not in the substance under examination.